Sky and TELESCOPE

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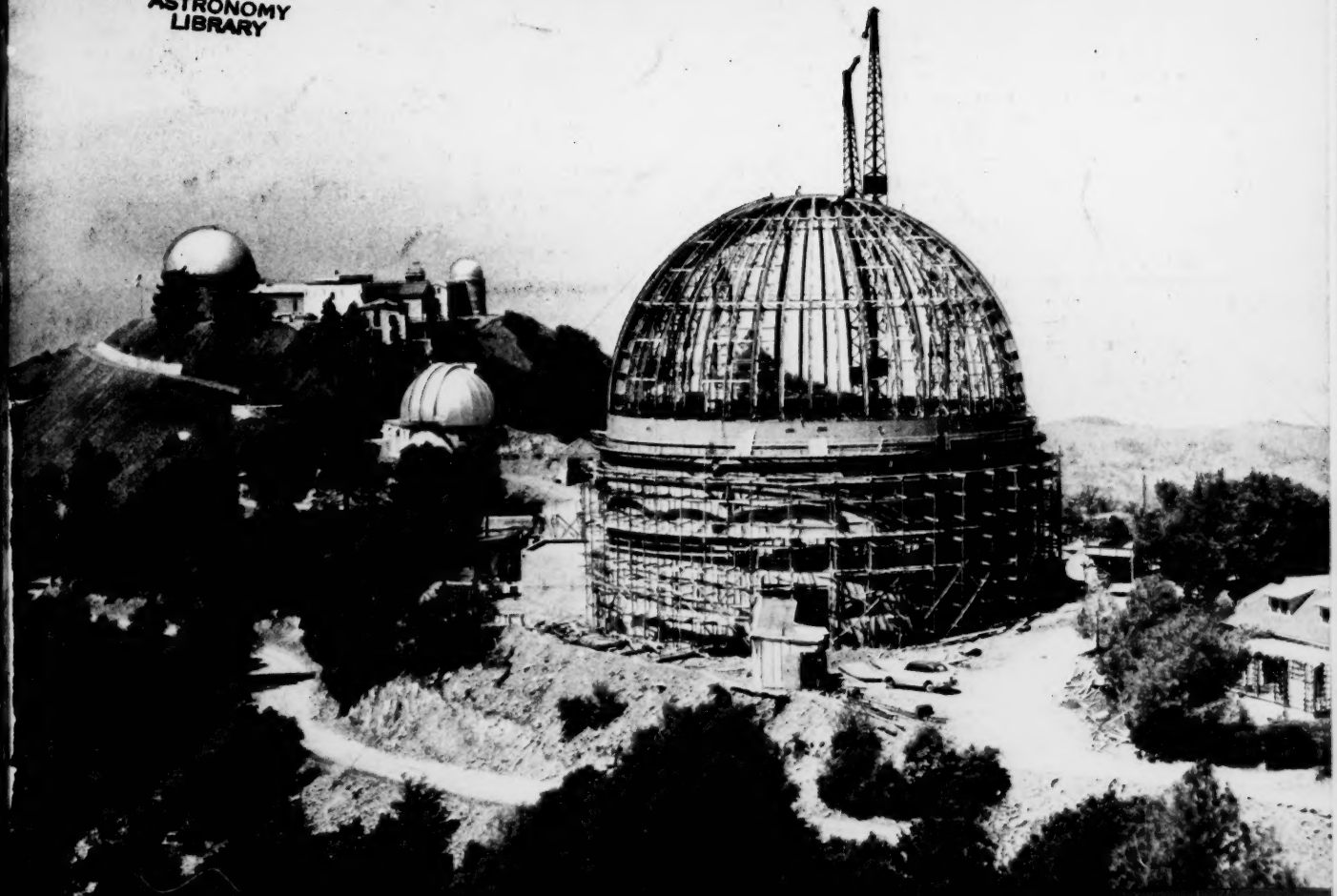

New 120-inch dome under construction

Expansion and Evolution of Star Clusters — II

Northern and Southern Star Charts

AN OPEN LETTER

Dear Amateur Astronomer:

Did we hear you ask, "What does my club have to gain from Astronomical League membership and what do we have to give?" This is not an unusual question for a non-member group to ask. Occasionally, too, we hear it from someone in a member organization.

Even as you ask the question, you must know how hard it is to give an itemized answer. You who have been active in your own local group know that you have derived satisfaction in direct proportion to the energy you have devoted to it. That is the way many of us feel about the league.

We have found from long experience that the exchanges generated by our regional and general conventions do more to promote cohesion among amateur clubs than anything else we have undertaken. Those who once attend a convention do their utmost to get to more such gatherings. They have developed close friendships far and wide with others who have similar astronomical interests. Even large societies, which may have considered themselves quite self-sufficient, through their representatives at conventions have learned much from a different approach, unique programming or special events as they are employed by some other group. The league encourages many projects among junior astronomers.

The league has promoted get-togethers on a smaller than regional basis too. Because the geographic area of the region may be too large for certain inter-group programs, this is an important part of league activity. Many folks go home from these gatherings bound and determined that the nucleus of a group that they know of in a neighboring city become organized and seek league membership.

It has been said, "If the league did no more than aid in the effective organization of new clubs it would still be counted as one of the assets of American astronomy, a major factor in the essential work of keeping the country conscious of the advantages of having a substantial number of scholars constantly attacking the most basic of all problems in the physical sciences."

This year's general convention will be held at the University of North Carolina at Chapel Hill. Whether or not you belong to a club that is a league member, come and see the annular eclipse of the sun and take part in the special demonstrations planned for the Morehead Planetarium. Come and see for yourself what the league is!

There are currently five regions of the Astronomical League: Northeast, Middle East, North Central, Northwest, and most recently organized, Mid-States. By September we may have another region in the Southeast, and we hope the Texas societies will soon organize a region.

Five times a year we issue the Astronomical League **Bulletin**. Since the club is the league member, each society receives a single copy of each publication. Beginning in September, 1950, the **Bulletin** was made available at cost to as many individuals as ordered them in advance. The Northeast region supplied individual copies to all adult members of its region. Elsewhere, some clubs paid the bill for copies for all their members; others asked their members to contribute the cost of the five issues and five stamped envelopes in which they might be individually mailed; others extracted material from the **Bulletin** and included it in their own local publications for their members. All of these methods have helped bring the league directly to the individual members of many organizations.

The activities section of the league has done a fine job of getting an observing program under way. An observing manual is in preparation, each contributor to be outstanding in his field. Observing chairmen have been or will be appointed by the individual clubs. In addition to aiding societies in observing the heavens for pleasure, we hope to develop some more of the tried-and-true workers who form the backbone of the national observing societies. A broader program of planning for society activity is now under way and will receive much emphasis at Chapel Hill.

Our technical advisory council is available to provide professional assistance when such is called for. This group will grow most valuable in bridging the gap between the professional and the amateur.

Maybe this is a small beginning. And we who are close to it are the first to admit that the Astronomical League is only in its infancy. Time and individual effort will develop it further. We know that many ideas and the know-how to carry them through are found in all local groups. You may have long had the point of view that the dissemination of an interest in astronomy and the development of amateur astronomers is a highly desirable sparetime activity. You may have tried to induce more and more amateurs to join your local club. We are taking the same point of view in trying to bring more amateur groups into league membership. Our aims and purposes are the same.

GRACE C. SCHOLZ
Executive secretary
Astronomical League

110 Schuyler Rd., Silver Spring, Md.

ED. NOTE: This letter, made available for publication at our request, expresses the spirit of the Astronomical League, which was founded in 1946. At that time Here and There with Amateurs listed 60 amateur societies; now it has grown to 101, of which more than half are members of the league.

Sky and TELESCOPE

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BACK COVER: The Horsehead nebula in Orion, IC 434, photographed on red-sensitive emulsion with a red filter with the 200-inch Hale telescope. The reproduction is enlarged about three times the scale of the original negative. South is at the top, east at the right (dark nebulosity side). Mount Wilson and Palomar Observatories photograph. (See In Focus and page 244.)

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ECLIPSE CHATTER

GENERAL NOTES

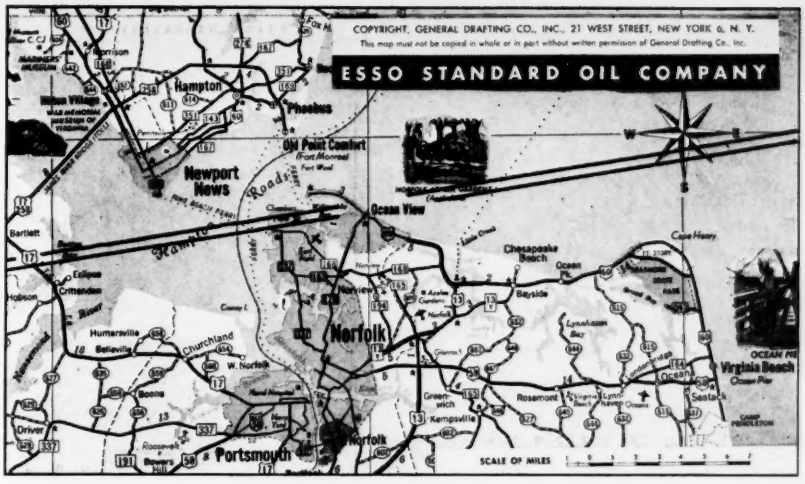
The second of two annular eclipses in 1951 will take place on Saturday, September 1st, and is of major interest to observers on the East Coast of the United States and Canada. The last such eclipse visible in this country was on April 7, 1940, when the annular path crossed the Gulf States.

Generally, the area east of the Mississippi River will see partial phases of the September eclipse, which will begin before sunrise except for points in eastern Maine. Mid-eclipse occurs at about 11:00 Universal time, corresponding to 5:00 a.m. Central standard time, 6:00 a.m. Eastern standard time, and 7:00 a.m. where daylight saving time is used in the Eastern zone. This time is correct within a few minutes for all localities in this country.

The maximum magnitudes of the partial eclipse are quite high, as shown by the following list of the percentage of the sun's diameter that will be covered by the moon at various cities. Parentheses indicate magnitude at sunrise, the maximum having occurred below the horizon:

Albany, N. Y., 82%; Augusta, Me., 78%; Cambridge, Mass., 83%; Cleveland, Ohio, 90%; Lake Angelus, Mich., 79%; New York, N. Y., 87%; Omaha, Neb., (22%); St. Louis, Mo., (52%); Syracuse, N. Y., 80%; Tallahassee, Fla., (68%); Washington, D.C., 92%; Williams Bay, Wis., (66%).

On the central line crossing North Carolina and Virginia, 96 per cent of the sun's diameter will be obscured. The sun's semidiameter is 15′ 51″, or 951 seconds of arc. Only four per cent of this, or about 38 seconds of arc, will remain unobscured by the moon at mid-eclipse along the central line. Thus, the ring will be very thin, but the annulus will appear quite bright and its apparent width will be increased by irradiation and by scattering in the atmosphere. The period of annularity will be slightly less than two minutes and 40 seconds. Times of second contact and duration of annularity for points where the eclipse is annular are given on page 196 of the June issue of *Sky and Telescope*.



The Norfolk-Virginia Beach area, with the central half mile of the path marked by the double line. The longitude of Cape Henry is 76° 00′ west; Ocean View, 76° 15′ west; Crittenden, 76° 30′ west. The latitude of Old Point Comfort is 37° 00′ north. Reproduced by courtesy of Esso Standard Oil Co.

In a telescope using filters, a solar wedge, or projection of the image, watch for the contacts, rapid motion of the annulus, possible prominences, and the black drop effect due to irregularities on the moon's surface. The contacts seem to pass rapidly, especially near the edge of the path. Photography should be attempted using telescopes or long-focus cameras, but exposures will vary considerably due to the low altitude of the eclipse and the amount of horizon haze and clouds. No filters at all may be needed for a time just after the sun has risen. Partial phases should be taken with the shortest exposures from 1/250 to 1/1,000 of a second and with the smallest aperture, f/22 or smaller.

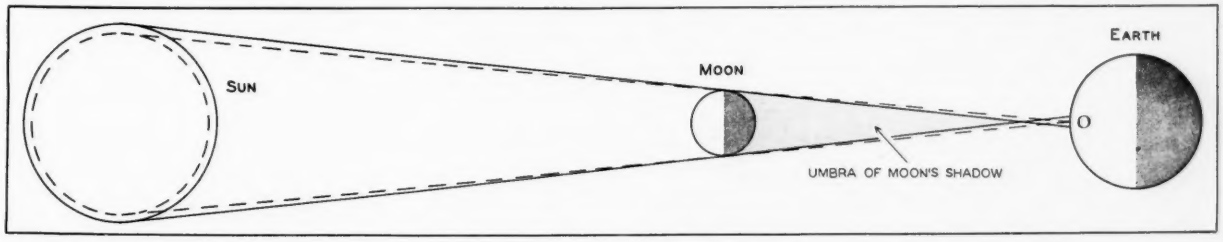
EDWARD ORAVEC

THE EDITORS EXPLORE

After attending the American Astronomical Society meeting in Washington, D. C., late in June, the editors toured into Virginia and along the central line of the annular eclipse path. Virginia Beach, though somewhat south of the central line, provides miles of easily accessible beach from which to have a clear ocean view of the rising sun. The roofs of some of the hotels and apartment houses are favorably tall. Although plentifully supplied with hotels, Virginia Beach will probably be crowded at this season, and anyone planning to stay there for a few days before the eclipse should make reservations promptly. The Virginia Beach Chamber of Commerce has stated that it will gladly supply hotel information on request.

Seashore State Park has excellent camping and bathing facilities, and its beach is as near the central line as the tip of Cape Henry, which is taken up by Fort Story, an army post. This is the site of the first federal lighthouse in the United States, and there is a weather bureau station on the post.

Route 60 along the north shore of the cape runs above Norfolk through the resort town of Ocean View, which is close to or on the central line. A fishing pier west of the Hotel Nansemond or the park near the Sarah Constant shrine should provide good eastward views. Farther west, probably below the central line, is the town of Eclipse, Va., on the shore near Crittenden (Route 17), between the toll



The manner in which an annular eclipse of the sun occurs. The umbra of the moon's shadow is too short to reach the earth's surface; an observer at point O sees the moon projected against the sun as indicated by the dashed circle on its disk.

bridges across Chuckatuck Creek and the Nansemond River. Eclipse does not seem to have an astronomical background for its name, and it is reputed to be the only post office with this designation in the United States.

U. S. Route 58 runs east and west not far from the central line (see the map in the June issue, page 196-7), and we drove west along it as far as South Hill. The highway is good, and should provide a means for moving east or west if necessary because of weather conditions. Observing from the highway east of Courtland would not be favorable, as the land is flat and local trees obscure the eastern horizon, but east of Emporia the land becomes rolling, and east and west of Lawrenceville the country is hilly. Ten miles east of South Hill and 14 miles east of South Hill there are strong ridges, and any of these locations might provide good emergency sites. From Norfolk to Lawrenceville took 2½ hours of driving time in the late afternoon.

STARS DURING THE ECLIPSE

On the morning of May 20th, I made some test observations from a ski hill near Rochester. The height of the hill was about the same as that of hills on the horizon, so the effect of dip could be disregarded. The sky was cloudless so that the sun could be seen the moment its upper limb pierced the horizon. A moderate haze in the valley enabled me to observe the sun without a filter.

The sky was that of a September evening, with Capella rising in the northeast and Antares setting in the southwest. With the unaided eye, Capella was last seen 35 minutes before sunrise (upper limb); Gamma Aquilae and Antares 24 minutes before sunrise; but Arcturus did not become invisible until nine minutes before the sun's upper limb rose. In an 8-power 2-inch telescope, Jupiter's bright moons could not be seen less than 31 minutes before the sun came up. Three minutes after sunrise, however, Capella was still visible in the telescope and Jupiter was visible to the unaided eye.

No attempt was made to see how long Capella and Jupiter could be detected after the sun was completely above the horizon, but these observations give me confidence that Regulus and many other stars will be visible during the annular phase. Pre-dawn observations the day before the eclipse should prove invaluable.

Incidentally, for the eclipse forum Saturday afternoon at Chapel Hill, I would like to call for stories and pictures of the March 7, 1951, partial eclipse, in addition to the expected reports of experiences the morning of September 1st.

PAUL W. STEVENS

WINSTON-SALEM ECLIPSE WEATHER BROADCASTS

For the annular eclipse of the sun September 1st, we are arranging for special weather broadcasts from the Weather Bureau office in Winston-Salem, N.C. These broadcasts will be given in co-operation with Station WSJS, Winston-Salem, on 600 kilocycles in the regular broadcast band and at 104.1 megacycles on FM. Reports over this station may be heard within a radius of 60 to 75 miles of Winston-Salem, and even farther at times, especially early in the morning.

A regular weather broadcast will be given at 6:06 p.m. EST, August 31st, followed by a special weather broadcast at 11:05 p.m. Another special broadcast will be given at 5:05 a.m. EST on Saturday, September 1st. On these broadcasts we shall include the state of the sky (whether cloudy, clear, and so forth), and the possible chance for obtaining a view of the eclipse at the following stations: Winston-Salem, N. C.; Greensboro, N. C.; Raleigh-Durham-Chapel Hill, N. C.; Elizabeth City, N. C.; Danville, Va.; Norfolk, Va.; Pulaski, Va.; and Richmond, Va. Also, sky conditions will be given at other places within the eclipse area, if obtainable.

Amateur astronomers at locations other than the above-named cities can render a great service by calling the Weather Bureau, Tel. 3-2250, Winston-Salem, between 4:30 a.m. and 4:55 a.m. September 1st and reporting the sky condition. The observer must pay for these calls, which cannot be made collect. This latest information will be broadcast on the 5:05 a.m. report. This will give an eclipse observer 50 minutes to move to a nearby location that may have clearer skies or better prospects of clearing. We would particularly appreciate a call from some observer at Pilot Mountain.

My personal interest in this eclipse, and in furnishing the above broadcasts, is due to my membership in the Forsyth Astronomical Society of Winston-Salem.

WILEY K. SIMS
Official-in-Charge
USWB, Winston-Salem, N. C.

NORFOLK AND RICHMOND WEATHER BROADCASTS

On August 31st, 10:45 to 11:00 p.m. EST, I shall do a broadcast over Station WTAR, Norfolk, Va., on 790 kilocycles. The broadcast will cover 10:30 p.m. weather conditions over the eclipse path and probable conditions at sunrise of September 1st. A story on the eclipse will also be contained in the broadcast.

Also, I expect to do a last-minute roundup on weather conditions as of 4:30 a.m. September 1st, over WRVA, Richmond, Va., on 1140 kilocycles. This broadcast will be near 5:00 a.m. and will originate in a Norfolk studio if I do it, but there is some possibility that it may be direct from the Weather Bureau airport station, Byrd Field, Richmond.

AUBREY HUSTEAD
USWB, Norfolk, Va.
A. A. S. of Norfolk

TERMINOLOGY TALKS.- J. HUGH PRUETT

Star Names

It is easy to believe that multitudes of primitive peoples who were a great deal under the night skies (shepherds with their flocks, wayfarers, and others), after often seeing certain stars, gave them names to suit their own individual fancies. We still do this today — to my small sister and me at our rural childhood home, before we learned the accepted name of a single star, Si and Little Si were just as meaningful as are Mizar and Alcor today.

Those in authority in government, science, or religion probably established accepted stellar designations, in many cases simply shortened forms referring to a certain section of a group or constellation. Thus, Achernar meant the end of the river; Denebola, the lion's tail; Enif, the horse's nose; and Algol, the ghost or the demon.

We often hear it said that most of the star names used today came originally from the Arabic. This is true. The excellent discussion of 183 stars by George A. Davis, Jr., in *Popular Astronomy* of January, 1944, shows, however, that many names are from other languages. Of Arabic origin are Altair, Deneb, Achernar, Vega, Betelgeuse, Rigel, Fomalhaut, Aldebaran, and Mizar. From the Greek come Arcturus, Sirius, Procyon, Canopus, Antares, and the nine named stars of the Pleiades. Of Latin derivation are Capella, Regulus, Bellatrix, Polaris, and Spica. The Persian claims Alcor, Alshain, Giausar, Sheliak, and Tarazed.

While most of us do not bother to learn the ancient proper names of more than two or three dozen heavenly bodies, yet occasionally we find an enthusiastic stargazer who goes "all out" on stellar designations. In my locality there are two middle-aged women, unrelated to each other, who put the rest of us to shame in their proficiency of locating and naming the fainter stars. They have a 12-inch illuminated Hammond celestial globe on which they found many new names. Then from my number of *Popular Astronomy* (mentioned above) one of them typed copies of Davis' list. Several times when a clear, moonless night has presented itself they have stayed out from dusk to dawn, communing with these distant orbs and noting their risings, movements across the sky, and settings. They speak freely of such unfamiliar stars as Izar, Mebsuta, Rotanev. One of them remarked to me recently, "We have become so good at this we can find no one around here with whom to talk about it but ourselves."

American Astronomers Report

Here are highlights of some papers presented at the 85th meeting of the American Astronomical Society at Washington, D. C., in June. Complete abstracts will appear in the Astronomical Journal.

Magellanic Superluminaries

Continuing the photometry of the supergiant variable stars in the Magellanic Clouds, Dr. Harlow Shapley, Virginia McKibben Nail, and William Tifft, Harvard Observatory, have made a survey of the stars brighter than apparent magnitude 13.1 in and around the Large Magellanic Cloud. At a distance of 80,000 light-years, this corresponds to a limiting absolute magnitude of −4.3, and the survey thus dealt with what Dr. Shapley describes as only "superlative luminosities."

A considerable number of non-variable stars of spectral classes *O, B,* and P-Cygni type, are found among these highest luminosities. In addition, 18 gigantic Cepheid variables, with diameters about the same as the size of Jupiter's orbit, were found. The periods of their pulsations vary from 24 to 172 days, and their candlepowers range from 8,000 to 21,000 times that of the sun. The variable of 172-day period, with a range of 2.8 magnitudes, may be a long-period variable of our own galactic system superimposed on the Magellanic Cloud — forthcoming radial velocity measurements will clarify the situation.

Nearly as luminous and voluminous as these Cepheid giants are half a dozen red irregular variable stars of the general type of Betelgeuse.

As in the case of the Small Magellanic Cloud, the superluminous stars of the Large Cloud are scattered widely, with no indication of concentration to its most populous regions. Some are actually more than four degrees from the cloud center.

Orbit of Nereid

The 30th satellite of the solar system and Neptune's second was discovered on May 1, 1949, by Dr. G. P. Kuiper, on plates taken at the prime focus of the McDonald Observatory 82-inch reflector. Since then, Dr. G. Van Biesbroeck has taken every opportunity to observe 19th-magnitude Nereid with this same instrument, the observations now covering three nights in 1949, eight in 1950, and eight in 1951.

He has determined rough elements of Nereid's orbit, which turns out to be of far greater eccentricity (0.76) than that of any other moon in the solar system. In the course of its 359-day swing around the planet, Nereid ranges from 830,000 to 6,100,000 miles from Neptune, the semimajor axis being 0.037255 astronomical units. The epoch of peri-Neptune passage was February 1.7, 1951. Referred to the plane of the ecliptic, the inclination of Nereid's orbit is only 4° 52′, and its motion is direct, from west to east.

Neptune's first-known satellite, Triton, revolves in a practically circular orbit 220,000 miles from Neptune. This orbit is inclined 140 degrees to the planet's orbit; thus, Triton's motion can be considered retrograde in an orbit inclined 40 degrees. Its period of revolution is 5.88 days.

To Nereid's elements corresponds a mass for Neptune of 1/18,730 that of the sun, which is about three per cent larger than Eichelberger deduced from the motion of the inner satellite. In a few years, the improved elements of Nereid will give a much more accurate value for this mass.

Mount Wilson Gratings

In fast stellar spectrographs, plane diffraction gratings blazed to concentrate the light into a selected spectrum order have almost entirely supplanted prisms. A completely mechanical single-screw ruling engine at Mount Wilson Observatory is now producing sizable diffraction gratings of high quality in all respects. Several recent gratings are 7¼ inches wide with grooves 5¾ inches long, and one is 8 by 5¼ inches.

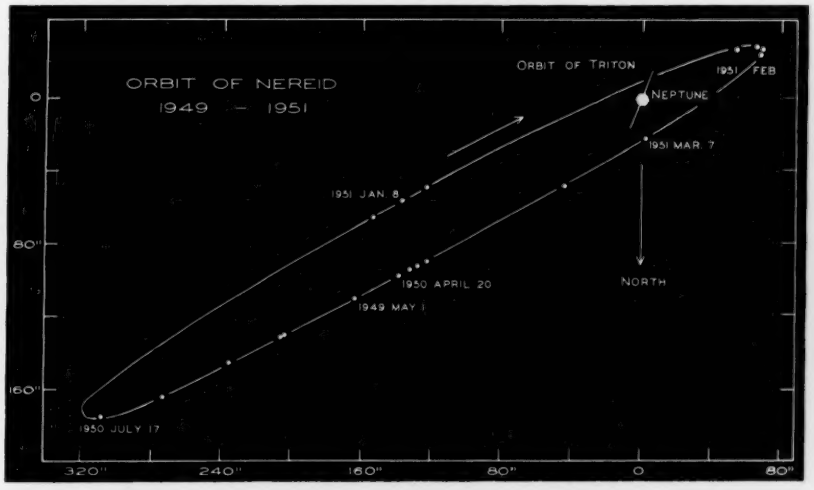
Drs. Harold D. and Horace W. Babcock, of Mount Wilson and Palomar Observatories, described the ruling engine and their methods of testing gratings. Curved-edge ruling diamonds, developed at Mount Wilson by Anderson 30 years ago, permit high luminous efficiency with practically complete absence of scattered light. Resolving power of 500,000 is achieved.

The rather considerable modifications of the Rowland-type engine were discussed, including the monorail diamond carriage, the coupling of the nut to the grating carriage, the end-thrust bearing of the screw, and the use of Nitralloy steel ways.

Hydrogen 21-cm. Radiation

In the vastnesses of interstellar space, a hydrogen atom may well be expected to be in its lowest energy state, with its single ring electron as close to the nucleus as it can be situated. Nevertheless, this atomic ground state has two energy levels, between which transitions occur as the electron assumes one of two positions in the weak magnetic field of the hydrogen nucleus. When this occurs, radiant energy is absorbed or emitted that is of very long wave length (21 centimeters) and low frequency (1420.405 megacycles).

One of the challenging problems of radio astronomy has been the possibility of detecting this transition in the spectrum of galactic radiations. Seven years ago, Dr. H. C. van de Hulst, of Leiden Observatory, predicted the existence of the 21-cm. emission line from interstellar hydrogen, and the Radio Astronomy Research Group in Holland, under the direction of Dr. J. H. Oort, had this line as its main project for the past two years. Dr. van de Hulst reported that C. A. Muller had observed the long-wave hydrogen emission on May 11th this year, at Kootwijk, Hol-



The orbit of Nereid, according to Van Biesbroeck, from McDonald Observatory observations. The discovery position was that of May 1, 1949.

land, using for an antenna an old German radar mirror seven meters in diameter.

Nearly seven weeks earlier, however, on March 25, 1951, Dr. Harold I. Ewen, of Harvard's Lyman Laboratory, detected this hydrogen radiation from the Milky Way. Dr. Ewen described his horn-type radio antenna of about 12 degrees half-power beam width, rigidly mounted at declination $-5°$, scanning being effected by the diurnal motion of the sky. The emission had a width of about 80 kilocycles, and was most intense in the direction of 18^h right ascension. The line is detectable, at $-5°$, over a period of about six hours during which the apparent temperature at the line center rises to a maximum of 25 degrees above the background and then subsides into it once more. Thus, this hydrogen radiation appears to come from an extended source approximately centered about the galactic plane.

Further confirmation of the celestial origin of the energy is that the period of its reception shifts two hours per month in solar time. Furthermore, the center frequency of the line, which was measured with an accuracy of five kilocycles more or less, was displaced some 150 kilocycles above the laboratory value. The shift and its variations are reasonably accounted for by the Doppler effect of the earth's orbital motion and the motion of the solar system toward Hercules.

The antenna used in Holland has a higher resolving power than Dr. Ewen's apparatus. It has a beam width of only two degrees and can be moved in all directions. Sweeps through the region of the galactic nucleus showed that at galactic latitude 8° to 10° north and south the intensity of the radiation dropped to half the maximum intensity. This Dr. van de Hulst attributes to nearby dark clouds in Ophiuchus at a distance of a few thousand light-years and probably opaque to this radiation.

Nevertheless, he considers one of the important uses of this discovery to be the ability of the radiation to penetrate clouds that are opaque to visible light. The portions of the line that are displaced by the velocity of rotation of the galaxy should come through any nearby clouds and show the gas structure near the galactic nucleus, which is about 30,000 light-years away. From the velocities of parts of the galaxy that are close to the nucleus, we should be able to make a precise determination of the concentration of mass in the nucleus. In addition, random velocities of interstellar gas clouds should be observable.

The discovery of the 21-cm. line enables us for the first time to observe hydrogen gas in the vast regions of space where it is neutral. There is as much matter in the spaces between the stars as there is in all the stars together, and most of it is assumed to be neutral hydrogen gas. Thus, we now have a means of studying the other half of matter in the galaxy. The distribution of this matter can give clues to the evolution of our galactic system.

The computed transition probability of the hyperfine structure of the hydrogen atom's ground state is so low that an interstellar atom in the upper level has to wait on the average 11 million years before by some chance process the electron spin is reversed and a radiation quantum of 21 centimeters wave length is emitted. The vast amount of hydrogen in space, averaging perhaps one atom per cubic centimeter, provides sufficient numbers of such transitions to produce the observed radiation, and to indicate a temperature of about 40 or 50 degrees above absolute zero in regions of neutral hydrogen.

Velocities of Type I Stars

Gravitational encounters between stars and interstellar clouds are proposed by Drs. Martin Schwarzschild and Lyman Spitzer, Jr., of Princeton University Observatory, to explain the spread of the velocities of stars of Baade's Population I, which are those presumably formed at comparatively recent times in the history of the galaxy. These are generally low-velocity stars, those of early spectral type averaging about 10 kilometers per second, while types *F* and later average 20 kilometers per second. (Some *M* stars of Population II may be mixed in to give the *M*-type Population I stars a velocity average of 30 kilometers per second.)

The Princeton astronomers suggest that the gravitational action of the interstellar clouds speeds up passing stars. This speed-up, which is the same for stars of all masses, arises from the tendency of the encounters to act towards equipartition of energy between clouds and stars, though at the present time equipartition must be far from reached.

In the extreme case that the largest cloud complexes acting as gravitational units should have masses of the order of a million suns, low-velocity stars may have been speeded up appreciably by star-cloud encounters during the past three billion years. If the actual masses of the large cloud complexes are, in fact, high enough to make this mechanism effective, we may suppose that all low-velocity Population I stars have been formed from interstellar clouds with initial average velocities equal to those of the present clouds (10 kilometers a second), and that the present differences in the velocities of these stars, described above, have been caused entirely by the encounters with clouds. Under this assumption, the encounters would have increased the average velocities of older groups (late dwarfs and red giants) by about two times, whereas they would not have had time to affect the velocities of the younger stars (early main sequence), which are probably only a few hundred million years old.

On the other hand, star-cloud encounters are incapable of changing noticeably the velocities of the fast-moving Population II stars. This may indicate that all these stars, with speeds on the order of 100 kilometers per second, were formed from the interstellar matter at an early stage, when the velocities of the primeval clouds were still high. The Population II stars are thus considered as old as the present universe itself, about three billion years.

The Princeton astronomers pointed out that this theory fits the fact that a few cloud stars (Population I) are very bright, sending out 100,000 times as much light and heat every second as the sun, while none of the primeval stars (Population II) surpasses 2,000 suns in energy radiated. Only young and profligate stars, burning their atomic fuel very rapidly, can shine as brightly as 100,000 suns; any primeval stars which were once so bright ran out of fuel several billion years ago and are now dark, invisible objects.

New Planetaries

From the favorable latitude of the Tonanzintla Observatory in Mexico, the Schmidt telescope there has been used to survey an area of nearly 600 square degrees around the galactic center in Sagittarius. The four-degree objective prism was used in taking 72 103a-E plates with a red filter that cut off radiation at nearly 6100 angstroms. The average limiting magnitude was 17.5.

Dr. Guillermo Haro, director of Tonanzintla Observatory, found in the area 437 objects with strong hydrogen-alpha emission. Of these, 121 correspond to planetary nebulae previously discovered, 67 are classified as new planetaries, and 48 are possible planetaries or, in a few cases, bright diffuse nebulae. The majority of the remaining emission objects are probably peculiar stars, too faint to be classified on Dr. Haro's plates. The number of planetaries to be found in this region seems far from being exhausted.

The planetaries now known are highly concentrated to the galactic center, with a marked tendency for symmetrical distribution with respect to the Milky Way equator. As with globular clusters, the three-dimensional system of these planetaries may be coexistent and concentric with the galactic nucleus. If this is true, the planetaries may provide us with an independent means to determine the distance to the galactic center and the probable dimensions of the nucleus of the stellar system.

Dynamics and Evolution of Star Clusters--II

By Bart J. Bok, *Boyden Station of Harvard College Observatory*

Dynamics and the Future of Dense Clusters

At one time, the writer and many of his colleagues thought that dense clusters would gradually "loosen up" through the energy transferred by passing field stars and that in the end even the densest cluster would reach the critical density for galactic disintegration and go the way of the Hyades or Ursa Major group. This has proved not to be the case. Ambarzumian in the Soviet Union and (independently) Spitzer in the United States showed that there is a second process that leads to eventual collapse of dense clusters rather than to disintegration.

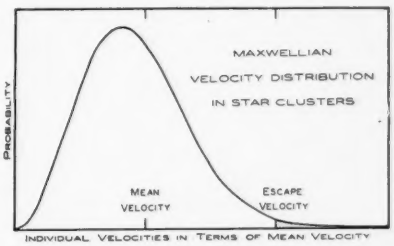
The Ambarzumian-Spitzer process depends on the importance for the evolution of the cluster of close passages of stars that are members of the system. If such an encounter between two cluster members results in a velocity for one of the participating stars in excess of the velocity needed for escape from the cluster, then the consequence will be that the escaping star takes with it more than its average share of energy, and that — because of the law of conservation of total energy — the average amount of energy per star for the remaining stars will be less than before the encounter. The cluster will, therefore, contract slightly as a result of the encounter. The problem is to calculate the rate at which this process takes place.

To do this, we use as an illustration an analogy between a cluster of stars and a cloud of gas molecules. In physics, the kinetic theory of gases shows that the gas molecules do not all have the same velocities, but that there exists a definite relation — known as Maxwell's law — for the spread of velocities around the mean. A similar distribution law of velocities probably applies to star clusters, where energy exchanges in distant encounters between pairs of stars take the place of the actual collisions in the case of gas molecules.

For the Maxwellian distribution law of velocities for stars in a cluster, we find that about one per cent of the stars have velocities in excess of the velocity of escape from the cluster. "Good riddance," one might say. But how long is it going to take before the Maxwellian distribution law, with its one per cent at the top end of velocities chopped off, is re-established in its old form? The time it takes to do this is known as the *time of relaxation,* and these times have been computed for all sorts of clusters. We might define the time of relaxation as the time it would take a cluster to readjust itself internally so that all trace of any major disturbance in the distribution of velocities is effaced. The "act of relaxation" is a continuous one, and in a way it is performed after every major disturbance, such as, for example, the escape of a star from the cluster. For the Pleiades the time of relaxation is of the order of 30 million years (one seventh of a cosmic year), whereas for a typical globular cluster it is about 10 billion years (50 cosmic years).

We can now return to our original question: How fast does the escape process make the cluster contract? The estimates of Ambarzumian and Spitzer, later refined by Chandrasekhar, show that the escape-and-contraction process will lead to the collapse of what remains of the cluster in periods of the order of a little more than 100 times the time of relaxation.

Quite recently, van Wijk at Harvard has made some detailed calculations about this process. The Pleiades are definitely headed for collapse, and will 25 cosmic years hence have shrunk to an inconspicuous small group of perhaps not more than 40 stars. For a cluster with half the radius of the Pleiades and one eighth the mass, a similar collapse will occur in only five cosmic years. Globular clusters and the like will be "safe" from collapse for several hundred cosmic years; the physical evolution of their individual stars will probably be far quicker than the dynamical evolution of the globular cluster as a whole.



The manner in which the velocities of stars in clusters tend to be distributed. About one per cent of the velocities are greater than that of escape from the cluster.

It is difficult to say what will be the future development of the remnant-nucleus of a collapsed cluster. The stars will be relatively close together, but there will still be enough room to prevent frequent star collisions. Probably

The globular cluster NGC 4372, situated in Musca at 12h 23m.0, —72° 24′ (1950 co-ordinates). Its stars are of magnitude 12-16, and it is of very low concentration, classified among the most open of all globulars. The bright star is of the 7th magnitude; its image is overexposed and surrounded by a ring caused by reflection from the back of the plate. This 60-minute exposure was taken with the Rockefeller 60-inch reflector in South Africa on March 12-13, 1937. Harvard Observatory photograph.

the remaining stars will form some sort of a super-multiple system in which the group stars move in complex periodic orbits.

Star Clusters and the Cosmic Time-Scale

In the accompanying table, we have tried to summarize our knowledge to date regarding the dynamical evolution of various kinds of star clusters. All estimated total masses are in terms of the sun's mass (2×10^{33} grams). The table shows again that, dynamically speaking, the globular clusters are very stable phenomena, but that the galactic clusters, especially those smaller than or more open than the Pleiades, are subject to fairly rapid changes on the cosmic scale.

On the whole, professional and amateur astronomers alike have always been more interested in the past of our universe than in its future. We wonder what we might deduce from the table regarding the probable past of the cluster system and of our Milky Way system, of which the clusters are a part. One fact stares us right in the face: An interval of 10 to 15 cosmic years is a significant one in the development of any galactic cluster, and presumably considerable changes must have taken place since our earth became solid 10 to 15 cosmic years ago! The life span of the earth may well have been a significant interval in the development of the universe of stars and galaxies.

There are three hypotheses — two of them extreme ones, the third a sort of compromise — that have received attention during the past 20 years and that concern the evolution of individual star clusters and the system they form in the galaxy.

HYPOTHESIS I. All galactic clusters that we observe today were formed during a cataclysm that must have occurred about 10 to 15 cosmic years ago, about at the time when the solar system, including the earth, was formed.

HYPOTHESIS II. Galactic clusters are being formed and die in a more-or-less steady progression, and the system that we observe today may be similar to that of 10 or 100 cosmic years ago (but with different clusters), and we shall probably find the same sort of system 10 or 100 cosmic years hence; evolution is a continuous and a continuing process.

HYPOTHESIS III. The majority of galactic clusters were formed about 10 or 15 cosmic years ago, but since this active early period of star and cluster building the process has continued and is continuing today at a diminishing rate; some of our present stars and clusters may be of quite recent origin.

Twenty years ago, shortly after the birth of the theory of the expanding universe and when we had just begun to realize the consequences of galactic rotation, there seemed to be much in favor of Hypothesis I. Hypothesis I was quite acceptable to the investigators of cluster dynamics, who felt that they could fit the clusters nicely into the short cosmic time-scale (10 to 15 cosmic years) as opposed to the long time-scale (500 to 1,000 cosmic years) that had been in vogue in the early 1920's.

Hypothesis I seemed also to have the support of pure physics. For there came increasing evidence for the presence, in our Milky Way system, of stars with masses of not more than 50 suns, yet radiating energy at a rate 1,000 to 10,000 times that of our sun. The subatomic energy pumps in these stars must be working overtime, and it seems impossible that these stars could have existed for as long as a hundred or more cosmic years. But, what at first seemed to provide the strongest support for Hypothesis I in the end proved to be its undoing. For it became evident a little more than 10 years ago that some of the spendthrift supergiants could not even be fitted into the short time-scale of cosmic development. Some of the fiercest radiators among the supergiants could hardly have existed for more than one or two cosmic years. Thus it became necessary to look into the possible processes of star creation since the days of the beginning of our earth.

Today, there are few astronomers who would not concede the possibility of the formation currently, or in the recent past, of some stars. Attention has been drawn to the presence of a good many small, roundish dark nebulae, *globules*, whose dimensions are of the order of several hundred to one or two thousand astronomical units, but which are very small on the scale of cosmic dimensions. Under the influence of radiation pressure from the outside, cooperating with their own tendency to contract under gravitation, these globules may well mark the beginning of new stars, or, as has been suggested by Whipple, a large dark cloud, like the southern Coalsack, may collapse piecemeal and form an occasional new cluster.

We are, however, not ready to accept Hypothesis II, that of continuous creation of stars and clusters. The known multiple star systems have very little of the appearance of remnants of collapsed clusters, and collapsed clusters should be quite abundant within a thousand light-years of our sun if Hypothesis II were valid. The strongest arguments against this hypothesis come from the physical side. The globular clusters, for example, have considerable numbers of fairly luminous giants (though none of the tremendous supergiants of which we spoke above) and apparently no cosmic dust — the stuff that evidently must be present for successful star building.

I should, therefore, like to propose that Hypothesis III be considered the working one of the moment. There are many divergent phenomena that point to the occurrence of some cataclysm two to three billion years ago, at the time when our sun and earth were presumably formed and when the universe of galaxies may have begun its expansion. But III has the advantage over Hypothesis I that it does not close the door to all subsequent star and cluster building, but recognizes the need for a continuing process, even though on a much-reduced scale.

Hypothesis III is capable of some fairly rigid tests in the next few years. The observing astronomer can continue his hunt for globules and newborn stars and study their properties. The search for collapsed clusters originally of the Pleiades variety should be pressed. The theoretical astronomer has a fruitful field of research open to him in the study of models of clouds of gas and interstellar dust particles — he may investigate just how these may gradually become luminous stars or clusters of stars.

THE END

Cluster	*Mass* (Sun = 1)	*Radius* (lt.-yrs.)	*Velocity Dispersion* (km./sec.)	*Time of Relaxation* (yrs.)	(cosmic yrs.)	*Effect of Galactic Tidal Forces*	FUTURE?
Globular cluster	10^6	50	12-15	10^{10}	50	None	Not much change during next 50 cosmic years
Pleiades	400	8	0.6	3×10^7	0.15	Probably slight	In 10 cosmic years, mass of 200 suns and radius of 3 light-years
Small, dense galactic cluster	50	4	0.3	8×10^6	0.04	Probably slight	Multiple star system: periodic orbits within 5 cosmic years
Nucleus of Hyades	150	16	0.2	10^8	0.5	Disintegration in 15 cosmic years	Disintegration in 15 cosmic years
Nucleus of Ursa Major cluster	100	75	0.1??	Irrelevant	Irrelevant	Disintegration in 2½ cosmic years	Disintegration in 2½ cosmic years

NEWS NOTES

By Dorrit Hoffleit

CURVIN H. GINGRICH

Curvin H. Gingrich, editor of *Popular Astronomy,* died of a heart attack in his 71st year on June 17th. A graduate of Dickinson College, after several years of teaching at both secondary school and college level, he went to Yerkes Observatory where he earned his Ph.D. from the University of Chicago in 1912. He had been associated with Carleton College, Northfield, Minn., since 1909, and was professor of mathematics and astronomy there from 1912 until his retirement a few years ago. On the editorial staff of *Popular Astronomy* since 1910, he became its editor-in-chief in 1926. From this work, which he obviously loved, he did not retire, and the editor's position will be difficult to fill with a person of his geniality and devotion. Many authors will remember his cordial gratitude for papers that were voluntarily contributed as well as for those that he had solicited.

Although Professor Gingrich was best known as the editor of *Popular Astronomy,* he also contributed to astronomical research directly, having made careful micrometric measurements of double stars, asteroids, and comets, determined stellar magnitudes, especially in the Hagen fields, and worked on parallaxes and proper motions.

RED SHIFTS: ONE FIFTH THE VELOCITY OF LIGHT

One of the major tasks Palomar astronomers had set for themselves was to determine whether or not the apparent law of the red shift would continue to hold for the much fainter, therefore more distant, galaxies. The extension of the spectroscopically observable region 50 per cent farther with the 48-inch Schmidt and the 200-inch telescope was reported in June to the Astronomical Society of the Pacific by Dr. Milton Humason, Mount Wilson and Palomar Observatories.

The Schmidt has discovered hundreds of clusters of galaxies where only 20 had previously been known. As the limit of this instrument is about 350 million light-years for the brightest galaxies in clusters, Dr. Humason believes that only chance discoveries with the 100-inch and 200-inch reflectors will reveal galaxy clusters at greater distances. But his spectroscopic observations with the Hale telescope confirm and extend the linear velocity-distance relation of the expanding universe: about 100 miles a second increase in recession for each million light-years additional distance.

These galaxies are so faint as to require exposures of four to six hours at the prime focus of the 200-inch. The spectra are only 1/10 inch long, and they are displaced by the red shifts about 1/20 inch. The red shifts of clusters at distances roughly estimated at 300, 330, and 360 million light-years were found by Dr. Humason to correspond to velocities of recession of 31,000, 34,000, and 38,000 miles a second, respectively. This last is one fifth the speed of light. Since the light we see now left these galaxies, the cluster may have migrated 70 million light-years deeper into space.

Whether or not the linear velocity-distance relation will hold for even more distant galaxies remains to be determined. This question is vital to the discussion of the age of the universe.

COSMIC RAYS

Primary cosmic rays — those as yet undamaged by collisions in the upper atmosphere — are now known to be composed of nuclei of all elements up to about atomic number 40, in the same relative abundances as in the sun and the major planets. In general, the heavier an element the less abundant it is, except iron, which is relatively frequent. Much as cosmic rays have been in the news, however, they increase the mass of the earth by only a hundred million millionth of one per cent in a billion years.

These are among the facts described by Edward P. Ney, University of Minnesota, in the May *Scientific American.* Plastic balloons carrying instruments higher than 100,000 feet recorded the heavy elements from space in recent joint experiments by cosmic ray workers of the University of Minnesota and the University of Rochester.

"At the latitude of Minnesota about 4,000 protons, 500 to 1,000 alpha particles (helium nuclei), 20 carbon nuclei and one iron nucleus pass through each square centimeter at the top of the atmosphere per hour," reports Dr. Ney.

The particles very nearly approach the speed of light as they enter the earth's atmosphere. Some have energies in excess of 20 billion electron volts, compared to 8,000 for the electrons that strike a television tube screen and six billion for the largest particle accelerator now planned on earth. At such great energies, we might expect to observe these heavy particles at lower levels in the atmosphere. But they dissipate their energies fast by ionization of the air; also, by collisions with the nuclei of atmospheric atoms that break them up into lighter particles. For example, in a collision observed in a cloud chamber, a carbon nucleus was broken into an alpha particle, four protons, and four neutrons (unobservable because of their neutral charge).

The heavy cosmic ray particles are characterized by both high energy and high ionization density of their tracks in specially thick photographic emulsions. It is possible for a high-speed proton and a slower iron atom to produce the same ionization if their speeds are properly related, but the penetrating power of the heavy iron is much the greater. These heavy-element cosmic rays are all stripped of their atomic planetary electrons. Their energies appear to be proportional to their positive charge.

To account for the observations, three classes of theory are current. One involves Lemaitre's explosion of the primordial atom; the second is that cosmic rays are being continually produced in the sun and stars; the third is that they are created by some other mechanism, as in magnetic fields in space. The mystery is as great as ever, but one point seems to be cleared up. Ney ends his article by a quotation from Karl K. Darrow:

"Millikan used to think cosmic rays were the death-cries of the elements, and now we find they are the elements themselves."

OFF ONE SECOND IN 30 YEARS

Extremely accurate quartz-crystal clocks have for some time been in operation at the Naval Observatory and at the National Bureau of Standards. Now another such clock has been put into operation at the Bell Telephone Laboratories at Murray Hill, N. J. Installed in air-conditioned rooms where the temperature should not change by more than two degrees, the clock is expected to vary by less than 1/10,000 of a second a day. If its present performance continues undisturbed, it should not be wrong by a whole second for about 30 years. The precision of the clock depends on four quartz crystals which vibrate at a constant frequency of 100,000 cycles a second to a precision of one part in a billion.

This clock will control radio broadcast network switching clocks and will be used by telephone companies to regulate equipment for coaxial cables and radio relay television and telephone networks.

INSECTS AND THE MOON

During five complete lunar cycles, C. B. Williams and B. P. Singh, at the Rothamsted Experimental Station in England, caught in an air-suction trap five times as many insects of all kinds during new-moon week as during full-moon week. Light traps had already indicated this as yet unexplained difference, and the British entomologists would welcome observations by others made by any method not involving light attraction. We think it would also be of great interest to discover whether there is any difference in how high insects fly on moonless nights and how far toward the moon they fly when it is full.

Amateur Astronomers

Mid-States Region Is Organized

THE REGISTER for the second annual convention of Mid-States amateur astronomers showed 53 in attendance, June 15-17 at the Morrison Observatory, Fayette, Mo. The societies at Wichita, Tulsa, Kansas City, Fayette (Central Missouri), and St. Louis voted to establish the Mid-States region of the Astronomical League, "with the stipulation that any other societies who are or will become members of the Astronomical League should be invited to join if they are within a reasonable distance of those above listed." Newly elected officers of this fifth region of the league are Russell C. Maag, chairman; Stuart O'Byrne, vice-chairman; W. P. Magruder, secretary-treasurer; and Dr. E. M. Brooks, councilor.

Although the Friday evening observing session and the Saturday morning solar observing were clouded out, motion pictures were shown instead. The Saturday evening star party included demonstrations of variable star work by Robert Adams and lunar and planetary work by John Reed and Mr. Maag. On Sunday delegates were able to observe the sun with the spectroscope attached to the 12-inch Clark refractor at Morrison Observatory, and in the afternoon the 7½-inch refractor at Laws Observatory of the University of Missouri was used for group sunspot observing during the open house there.

Feature talks were given by Dr. Frank Edmonds, Laws Observatory, on "Photoelectric Photometry with Small Telescopes," and by Dr. C. C. Wylie, University of Iowa, at the banquet, on "Stone-Dropping Meteors and Their Meteorites." A dozen other papers were presented during the convention, on the visibility of penumbral lunar eclipses, meteors, the history of Morrison Observatory, variable star observing, co-operative observations of the St. Louis society, and other topics.

The 1952 regional meeting will be held at St. Louis, with the St. Louis A.A.S. and the A.A.S. of the Emerson Electric Co. as co-hosts.

KEY TO PHOTOGRAPH

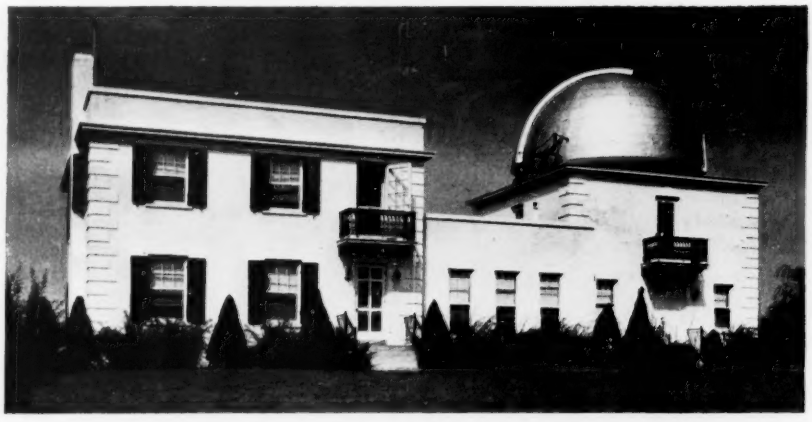
Back row, left to right: W. Hughes, Cl; M. Kinsey, K; Dr. F. Edmonds, C; Dr. E. M. Brooks, S; S. O'Byrne, S; C. E. Brown, K; T. Adams, Kirkwood, Mo.; R. C. Brown, Eureka, Ill.; Dr. F. Helton, F; R. Adams, Neosho, Mo.; J. Reed, C; R. C. Maag, Fulton, Mo.

Middle row, left to right: Mrs. Hughes, Cl; E. D. Tarbell, Devils Elbow, Mo.; Dr. R. T. Dufford, Marshall, Mo.; Dr. H. A. Bulger, S; Dr. E. S. Haynes, C; Dr. C. C. Wylie, Iowa City, Ia.; E. Friton, S; W. P. Magruder, K; R. E. Follett, Kansas City, Kans.; J. E. Boyd, S; M. Ridder, Quincy, Ill.; H. F. Sassenberg, S; F. A. Keysor, La Grange Park, Ill.; R. Miller, Merriam, Kans.

Front row, left to right: Mrs. B. L. Judd, Ardmore, Okla.; Mrs. Kinsey, K; Mrs. Follett, Kansas City, Kans.; Miss D. Chenoweth, F; Mrs. Magruder, K; Mrs. Helton, F; Miss G. Tydeman, Manchester, England; Mrs. Wylie, Iowa City, Ia.; Dr. S. B. Hughes, Cl; T. P. Bedford, F; O. Anderson, Davenport, Ia.; C. E. Miller, Independence, Mo.; R. Hyman, K.

Children, left to right: Jimmie Hughes, Jerry Friton, Phillip Helton.

C, Columbia, Mo.; Cl, Clinton, Mo.; F, Fayette, Mo.; K, Kansas City, Mo.; S, St. Louis, Mo.



The Morrison Observatory of Central College, Fayette, Mo.

The Mid-States convention of amateur astronomers. Central College photograph.

WESTERN AMATEURS TO MEET IN SAN DIEGO

The third annual convention of western amateur astronomers will be held in the Puppet Theater, which is in the Palisades Building in Balboa Park, San Diego, August 13-15. The host societies are the Amateur Telescope Makers and Astronomical Club and the Astronomical Society of San Diego.

The convention banquet Monday evening will be served on the terrace at the "House of Hospitality," also in the park. Regular luncheons and dinners will also be served there, and breakfast if a sufficient number of delegates desire it.

The chairman of the convention committee, Carl W. Dickson, 6951 Mt. Vernon St., Lemon Grove, Calif., would like advance notice, if possible, from those expecting to attend the convention. He states that adequate transportation is assured for the trip to Palomar Mountain on the last day of the convention.

THIS MONTH'S MEETINGS

Cambridge, Mass.: The Amateur Telescope Makers of Boston will hold summer outdoor meetings with members' telescopes on Friday, August 10th, 7:30 p.m. at the Mt. Ida School, Newton, and on Saturday, August 25th, at 3:00 p.m. at Harvard Observatory, when picnic lunches should be brought.

Columbus, Ohio: The Columbus Astronomical Society will meet at 8:00 p.m. on August 10th at McMillin Observatory, when Philip Stanger will speak on "The Outer Spaces."

Dallas, Tex.: The Texas Astronomical Society will hold its third field meet of the season on August 27th, 8:00 p.m. at the home of Mr. and Mrs. Ralph Ingraham, 2720 Poinsetta Drive.

NEW LEAGUE MEMBERS

A new member organization of the Astronomical League is the Amateur Astronomical Society of Union County, with 28 members. Mrs. Carl T. Bochau, 236 Normandy Village, Union, N. J., is general secretary.

The Denver Astronomical Society, with 20 members, has also joined the league. The corresponding secretary is Willard E. Johnson, 264 S. Gilpin St., Denver 9, Colo.

Astronomical League Chapel Hill Convention Program

Eastern standard time	
	Friday, August 31
3:00 to 10:00 p.m.	Registration, Morehead Building — Elizabeth Fazekas. Setting up exhibits, same room — T. W. Stone.
4:30 to 6:00 p.m.	Get-acquainted hour, Faculty Lounge, Morehead Building — Mrs. Z. V. Conyers.
5:30 to 6:30 p.m.	Council meeting.
8:30 to 9:30 p.m.	"Eclipses of the Sun," Planetarium show; admission, 18 cents for children, 50 cents for adults.
9:30 p.m.	Outdoor observing — Maurice Parson.
	Saturday, September 1
4:45 a.m.	Leave for eclipse observing site.
5:48 a.m.	Sunrise.
5:58.5 a.m.	Middle of annular eclipse.
9:00 a.m.	Registration, Morehead Building. Setting up exhibits.
9:00 to 10:00 a.m.	Middle East regional meeting, Howell Hall. Meeting of Southeastern societies, Faculty Lounge.
10:20 a.m. to 12:00	Opening convention session. Welcome by Dr. Douglas Duke, University of North Carolina. Reports of member organizations.
1:30 to 3:30 p.m.	Eclipse forum — reports by annular eclipse observers.
3:30 to 3:50 p.m.	Junior session.
4:00 to 5:00 p.m.	Instrumentation session.
7:00 to 9:30 p.m.	Convention dinner, Carolina Inn. Presentation of Astronomical League award. "The Development of the Vanderbilt University Observatory," Dr. Carl K. Seyfert.
	Sunday, September 2
9:00 to 10:30 a.m.	Inspection of exhibits; public invited. The balance of the morning is free for church attendance.
1:30 to 2:30 p.m.	Solar system session.
2:30 to 3:00 p.m.	Additional eclipse reports. Election of officers.
3:00 to 3:30 p.m.	Convention group photograph.
3:30 to 5:00 p.m.	General session for papers.
7:30 to 9:30 p.m.	Club projects. Reports of the past year and plans for the future, Charles H. LeRoy, president, Astronomical League, and Rolland R. LaPelle.
9:30 to 10:30 p.m.	Council meeting.
9:30 p.m.	Outdoor observing — Maurice Parson.
	Monday, September 3
8:30 to 9:30 a.m.	Middle East regional meeting, Howell Hall. Southeastern societies meeting continued, Faculty Lounge.
9:30 to 10:30 a.m.	General session. Selection of convention site for 1952.
10:30 a.m. to 12:30 p.m.	Simulated observing, Morehead Planetarium chamber: Meteor Observing, Edwin F. Bailey; Drawing the Moon, Rolland R. LaPelle; Variable Stars, John W. Streeter.
12:30 p.m.	Council meeting.

THIS program is abbreviated from more complete information received from G. R. Wright, convention chairman. Dormitory accommodations for Friday, Saturday, and Sunday nights are still available, at $2.75 per night for a single room, $4.00 for a double room. A deposit of $5.00 per person is required, payable to Elizabeth Fazekas, convention treasurer, to be sent to her at 3309 Scott St., Portsmouth, Va. A late reservations charge of 50 cents per person is added each month after July 1st. The balance due will be payable upon arrival at the convention. Refunds for cancellations will be made after the convention. As of July 4th, advance registration totaled 102 persons, listed below:

California, *Los Angeles*, H. A. LeVaux. Connecticut, *North Haven*, Lillian Budd, Mr. and Mrs. F. Velardi, Miss F. Welter. District of Columbia, Mrs. Ione Alston, Thelma Cressy, Mrs. R. W. Gearce, Margaret Glock, Ruth Heisey, E. Jones, R. McCabe, Janet Perkins, Mabel Sterns.

Georgia, *Atlanta*, C. Holton; *Columbus*, Dr. and Mrs. F. Schley; *Decatur*, Dr. W. Calder; *Moultrie*, R. Bingham. Illinois, *Moline*, Mr. and Mrs. C. Gamble. Kentucky, *Louisville*, Mr. and Mrs. J. Ralph, Mr. and Mrs. C. Strull.

Maryland, *Chevy Chase*, H. Alvord; *Greenacres*, G. Borreson, Mr. and Mrs. L. Scott; *Kensington*, Irene Warthen; *La Plata*, L. Johnson; *Silver Spring*, Grace Scholz, G. R .Wright, T. Wright. Massachusetts, *Cambridge*, Mrs. Nancy Bolton and daughter, Betty Dodd, Mr. and Mrs. C. A. Federer, Jr., and family, O. Gingerich; *Marblehead*, J. Knowles; *Quincy*, Mr. and Mrs. H. Chase; *Wellesley*, Mr. and Mrs. G. Keene.

Michigan, *Lansing*, E. Carlson, Mr. and Mrs. M. Parson. Mississippi, *Vicksburg*, Mrs. A. Bonelli. Missouri, *Overland*, Mr. and Mrs. E. Brooks; *St. Joseph*, J. Moore; *Webster Groves*, J. Boyd. New York, *Delmar*, R. Thomson; *Elmhurst*, H. Luft; *Great Neck*, J. Eichberg, Jr.; *New York*, C. Cuevas, A. Hershfeld, E. Oravec, K. Weitzenhoffer; *Pittsford*, Mr. and Mrs. R. Oakin; *Rochester*, E. Root, Mr. and Mrs. P. Stevens; *Schenectady*, Gladys Carr, C. Johnson.

North Carolina, *Charlotte*, Mr. and Mrs. L. Kelly; *Greensboro*, Mrs. Z. V. Conyers, T. Street. Ohio, *Cleveland*, G. Green. Pennsylvania, *Baden*, Mr. and Mrs. T. LuCaric and son; *Petrolia*, J. Hawk; *Philadelphia*, E. Bailey, Mr. Bennett, Mr. Klein, J. Streeter, Eleanora Vadala; *Pittsburgh*, Mr. and Mrs. C. LeRoy and sons.

Texas, *Dallas*, E. Brewer, T. Gangl, W. Gilliland. Virginia, *Newport News*, Mr. and Mrs. R. J. Wicke; *Norfolk*, P. N. Anderson, N. Bedinger, Mr. and Mrs. N. Hufnell; *Portsmouth*, Elizabeth Fazekas; *Richmond*, Lillian Sievers. Wisconsin, *Oshkosh*, Mr. and Mrs. R. Buckstaff and daughter. Canada, *Toronto*, E. Greenwood.

JUPITER - The Nature of Strength

With ponderous aplomb the portly Jupiter
Plods his proud and pompous path apace,
A corpulent presumption in his posturing,
A pregnant look of power in his face.

The largest planet in the solar system,
He deems himself important in proportion,
With "pull" in space he plays the politician,
Involved in gravitational extortion.

But influence and size are not compounded,
And when of bulk a major part is gas,
Attractiveness is likely to diminish,
Since force pertains to density and mass.

So smaller spheres of sounder substance manage
To count for much as they pursue their course,
And even to reflect more brilliant sunlight,
By circulating closer to the source.

Throughout the sternly geometric heavens
There spreads an impish curvature of pleasure,
Acknowledging that power reigns elusive,
And force denies dimension as its measure.

S. C. Florman

THE INDEX TO VOLUME X

of **Sky and Telescope** will be included in the October, 1951, issue. It will be abbreviated in form compared with former indexes, but all subscribers will receive it without extra charge. The index may be removed from the issue for binding at the front or back of a complete 1950-1951 volume.

The more detailed, cross-referenced indexes to Volumes I through IX are still available, postpaid for 35 cents each, in coin or stamps.

SKY PUBLISHING CORPORATION
Cambridge 38, Mass.

Clouds with Silver Linings

By Otto Struve, *Berkeley Astronomical Department*
University of California

About 30 years ago, John C. Duncan started a program of photographing with the Mount Wilson 60-inch and 100-inch telescopes the most spectacular nebulae and clusters of the accessible part of the sky. In the course of this work he obtained several pictures of the nebulous regions surrounding the star Zeta Orionis, at the southeastern end of the belt of Orion. Sir William Herschel had listed these nebulae as No. 28^5 in his catalogue of 52 nebulous regions in the sky.

One of the most remarkable features of these formations is the great mass of opaque cosmic dust which forms the Horsehead nebula. Although earlier observers had seen and photographed it, Duncan was the first to describe it as a "dark cloud . . . along whose western edge a notable *silver lining* is shown." A recent photograph of the Horsehead nebula, taken with the 200-inch Hale telescope, is reproduced on the back cover this month.

Since then many similar "clouds with silver linings" have been discovered. As a rule, they appear in connection with those gaseous nebulae which exhibit spectra of the emission type, as distinguished from other diffuse nebulae whose spectra represent the reflected light of the stars embedded within their boundaries. The emission nebulosities are associated with bright stars of very high temperatures. Such stars possess a large amount of invisible ultraviolet light, which is capable of inducing the atoms within the nebula to glow in their characteristic monochromatic radiations. The cooler stars have less ultraviolet light, and they do not produce emission lines of glowing hydrogen, oxygen, nitrogen, and so on. Instead, the visible light of these stars is scattered by the particles of the nebula without significant change, just as on a foggy night the atmosphere scatters the light of a street lamp, producing a feeble illumination around it.

The Orion nebula and the background nebulosities near Zeta Orionis are of the emission type. The nebulae in the Pleiades are of the reflection type. There are a few intermediate cases; for instance, the nebulae near Sigma Scorpii shine partly by reflected starlight and partly by the discrete nebular radiations.

These cosmical clouds with silver linings have been the subject of several investigations in recent years. It is generally agreed that the origin of the narrow luminous rims along the edges of the large, dark masses is quite different from that of terrestrial clouds with silver linings. The latter are seen when the sun is hidden by an opaque cloud, placing the observer, the cloud, and the sun almost on a straight line. The main mass of the cloud absorbs almost completely the incident light of the sun, and we observe essentially a dark mass, illuminated only by the diffuse light of the sky. But at the edges of the cloud, where the density of water droplets is small, the rays from the sun experience, as a rule, only a single reflection. Thus they produce an intensely luminous layer, brighter even than the usual blue background of the sky, which is caused by multiple processes of reflection or scattering from molecules of air.

The cosmical silver linings are far too numerous, in any large nebula, to be explained in this manner. An occasional object might have a luminous edge because of light reflected or diffracted from a star that is itself hidden by the dark mass. In the majority of cases the clouds with silver linings are oriented toward bright stars or clusters associated with the nebulae, and the angles formed at the silver linings between the directions toward the earth and the exciting stars are not much larger than 90 degrees — which is very far indeed from the angle of almost 180 degrees that is characteristic for the terrestrial phenomenon.

The most recent study of the cosmical objects is by A. D. Thackeray, and represents one of the first spectrographic investigations made with the 74-inch Radcliffe reflector in Pretoria, South Africa (*Monthly Notices* of the Royal Astronomical Society, *110*, 343, 1950). Several nebulae with bright rims were observed, but most of the results refer to one of the most beautiful objects of the southern sky, No. 16 in Messier's catalogue, or No. 6611 in the *New General Catalogue* by Dreyer. This remarkable nebula (reproduced on pages 246-247 from a recent 200-inch photograph) is located in the constellation Serpens at R.A. $18^h\ 13^m.1$, Dec. $-13°\ 51'$. It was discovered in 1764 by Messier, who described a cluster of bright stars "mixed with a feeble light." The nebula was detected photographically by E. E. Barnard in 1895, and by I. Roberts in 1897.

Duncan, who published in 1920 a photograph obtained with the Mount Wilson 60-inch reflector, remarked that the nebula was easily visible with the 12-inch refractor of the Whitin Observatory of Wellesley College. He also noted that "the most interesting feature disclosed by the photograph is the system of sharply defined dark markings of which the most conspicuous is on the southeast side, extending inward beyond the center. This marking so resembles the result of irregular flow of developer that, when it appeared on an earlier negative, its reality was questioned until it was fully verified by the present plate. The nebulosity in a thin line lying along the northern rim of the great dark marking is brighter than elsewhere."

Actually, this nebula contains several conspicuous bright rims, and it was the study of these rims that formed the major portion of Thackeray's investigation. His principal conclusion is that the spectra of the bright rims are generally similar to the emission spectra of the structureless diffusely glowing background of the nebula as a whole, but that the hydrogen lines are relatively stronger than the so-called nebular lines, which are produced by forbidden transitions of doubly ionized oxygen. The hydrogen atoms require less energy to become luminous than do the oxygen atoms, and the difference detected by Thackeray would indicate a lower degree of ionization in the rims than in the rest of the nebulous mass. But differences in ionization may be produced by several physical causes, such as lower temperature or greater density. Hence, we cannot immediately translate the observed ratios of line intensities into ordinary physical quantities. In the planetary nebulae, for example in the Ring nebula of Lyra, the nebular lines are much stronger than the hydrogen lines. This is probably due to the very high temperatures of the central stars of the planetaries. The exciting stars of ordinary, diffuse galactic nebulae are usually ordinary *O* and *Bo* stars, which have not quite such high surface temperatures.

Thackeray leans heavily upon a stimulating hypothesis proposed in 1946 by J. H. Oort in his George Darwin lecture in London. The interstellar clouds of dust and gas are immense, irregular condensations within the much more tenuous substratum of the galaxy. An average cloud has a diameter of about 100 light-years, and is separated by a distance of roughly 200 light-years from its nearest neighbor. These clouds participate in the general rotation of our entire galaxy; but they have individual motions also, distributed at random, which average about 15 kilometers per second. Oort estimates that any given cloud would collide with another cloud, about once every 10 million years, in such a way that their relative motions would be destroyed.

In the process of such a collision of two cosmic clouds, heat is generated and a narrow compressed region is formed between the two clouds, where the energies released by the collisions of the individual particles are transformed into light. The gaseous atoms which

were present in the original gas, or which were evaporated from the colliding dust particles, start emitting their characteristic radiations, and a strong line spectrum results. This *may* have entirely different properties than the emission-line spectra in quiescent nebulae that are produced through the transformation of ultraviolet starlight into visible, discrete emissions; this latter process is known as the Zanstra-Menzel mechanism of nebular radiation.

Oort concluded: "It is tempting to suppose that it is this strongly luminous interface, and more particularly those parts of it which are perpendicular to the plane of the sky, which causes the bright rims frequently observed near dark nebulae when these are bordered by luminous nebulae, and that the adjacent thin luminous fields represent the compressed regions of the thinner of two colliding clouds. The luminescence of nebulae like the well-known extensive nebulosities near Zeta Orionis or the North America nebula, may well be caused by this collisional mechanism, rather than by radiation from stars."

Thackeray's spectroscopic results, which are mostly confirmed by earlier observations of H. van de Hulst at McDonald Observatory, lend no decisive support to this hypothesis. But they do not disprove it, for it is possible that the spectrum of the collisional process differs but little from that produced by the Zanstra-Menzel mechanism. Hence, Thackeray rests his case principally upon the *appearance* of the clouds.

There are heavy "curtains" of long straight bright rims which often form the boundaries between bright and dark areas. Dark lanes sometimes cross the line of these curtains, forming break-throughs which in turn are bordered by brilliant rims. These lanes are usually pointed toward a bright central star, or group of stars near the center of the nebula, and the rims are always brightest at the tips nearest to these stars. The widths of the bright rims are of the order of two or three seconds of arc, which at the distances of these nebulae corresponds to several thousands of astronomical units.

The break-throughs suggest motion of dark material toward the central cluster of stars, but there are as yet no proper motions, nor even radial velocities, to support this visual impression. If the motions exist, then presumably the bright rims are caused by the collision of the dark masses of the break-throughs against the more tenuous medium of the nebula proper.

In the absence of any convincing spectroscopic proof (the slight diminution of ionization at the rims might be due to the greater density of the material in the dark masses), a rather serious objection to the collisional explanation is that luminous rims are never

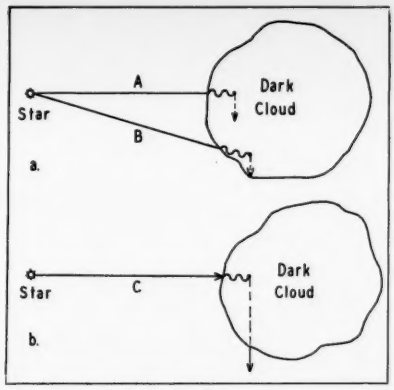


Fig. 1. Ray A is absorbed in the cloud, with no emission of light of a different wave length. Ray B penetrates a short distance into the cloud and escapes again through a thin layer. Ray C, however, represents transformed radiation that may escape from some short distance in the cloud, giving the bright-rim effect.

observed in ordinary dark clouds like those in Taurus or in the Scorpius-Ophiuchus region. These enormous masses have all the indications of chaotic, turbulent motions. They are torn and twisted in all directions; collisions between different parts of these clouds must be frequent occurrences. Yet, no trace of emission spectra has ever been observed in them. Even where they are illuminated by stars that are too cool to set the Zanstra-Menzel mechanism into operation, there are no bright rims!

Perhaps the explanation of the rims requires no collisions. Suppose that in

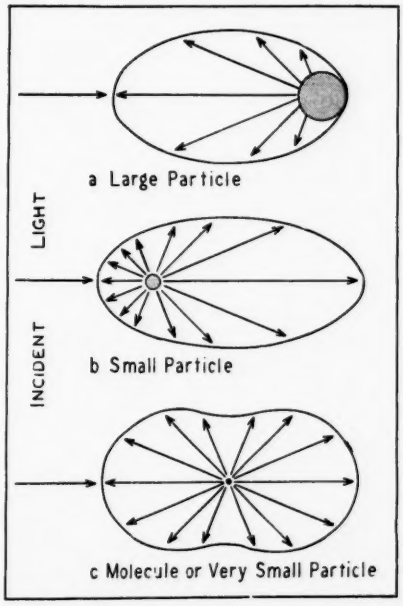


Fig. 2. The scattering of light by particles of different sizes. Interstellar cloud particles should behave as the small particle here, scattering most of the light forward.

Fig. 1a, a ray of light (*A*) from a bright star enters the dark cloud and is rapidly absorbed by the latter's ability to scatter the incident ray in various directions. If there is no transformation, the light scattered in the direction of the observer is soon lost within the dark mass by the same process of scattering. Ray *A* never reaches the observer. Only a ray such as *B*, which strikes the dark mass at the edge nearest to the observer, gets out and is observed as a faint surface brightness; there is no brilliant rim.

But if, in Fig. 1b, ray *C* while being scattered is converted into light of, let us say, the nebular lines of doubly ionized oxygen, then these latter radiations may pass through the material of the dark mass almost unobstructed. The dark cloud is probably much less absorbing for the light emitted by the oxygen atoms than for the continuous ultraviolet light coming from the star. *C* and all other similar rays entering a thin outer shell of the dark cloud pass out of the latter and combine to form an intensely luminous rim. The transformation of ultraviolet continuous starlight into visible atomic line radiations would thus be required to produce the phenomenon of silver linings.

This explanation is also beset by one or two objections. We do not definitely know that the material of a cloud is transparent to the atomic emissions of oxygen, hydrogen, and other elements. If the cloud consisted entirely of gas this would be a reasonable assumption. But if the cloud consists *mostly* of solid particles, then the absorption of *C*, after scattering, would differ little from that of *A*.

It is not impossible that we shall be led, ultimately, to adopt a combination of the two hypotheses. It may well be that the collisional process is required to produce a gaseous fringe at the edges of the break-through, by the phenomenon of evaporation.

Thackeray refers in his paper to another kind of "silver lining" which superficially resembles that of the bright rims in M16. Many years ago astronomers at the Yerkes Observatory noticed that the dark clouds in Taurus, Ophiuchus, and Scorpius, are intensely black in their central regions, and slightly luminous near their edges. These luminous edges are not as narrow as are the rims in M16, nor do they have spectra of the emission type. The dark markings are not associated with any bright stars that can illuminate them. Neighboring clouds lying near Rho Ophiuchi and Alpha Scorpii are indeed illuminated by these stars, producing reflection nebulae, but it is only in clouds that are hundreds of light-years away from these stars that the peculiar phenomenon of "limb brightening" is observed.

The dark clouds receive some light

from the mass of faint stars which surround them. This diffuse illumination, coming from all parts of the sky as seen from the cloud, is comparable to that produced by our own starlit sky on a moonless night. The resulting illumination is not at all negligible. A piece of white paper stands out clearly, and very large print, such as the headlines of a newspaper, can be distinguished by a dark-adapted eye. Hence, a dark cloud, consisting of small solid particles and free atoms of gas, should look to us as a cloud of fog seen from a mountaintop on a clear starlit night. It should be faintly luminous, and not completely dark.

In order to explain the brightening at the edges of dark nebulae, we must consider the properties of the scattering particles. A large particle (10 microns or larger) acts as an illuminated planet or satellite. It scatters most light back toward the source, and no light whatever in the forward direction of the beam (Fig. 2a). Small solid particles (one micron or less) throw most light in the direction of the beam (Fig. 2b). This type of scattering is related to the phenomenon of diffraction. It is the cause of many traffic accidents at night. A cloud of fine dust over a road illuminated by the headlights of your car appears dazzlingly bright to the driver of an approaching car, but may not blind you at all! Extremely small solid particles, and free molecules in a gas, scatter equal amounts forward and backward, but only half as much at right angles to the beam (Fig. 2c).

The interstellar particles of a cosmic cloud behave as in Fig. 2b; they scatter most of the light forward.

Now consider an opaque cloud of approximately spherical shape (Fig. 3). A particle, *Q*, near the "front" of the cloud receives light from an entire hemisphere, the solid arrows indicating that the amounts of incident radiation are nearly the same from all directions. Each arrow is scattered mostly in its own forward direction. The resulting pattern of the summation of all the scattered arrows will give a distribution such as is shown by the dotted arrows. Most of the light is directed inwards, where it is ultimately lost because of

The irregular nebula and cluster Messier 16 (NGC 6611) in Serpens, photographed with the 200-inch Hale telescope. Note the numerous dark lanes that end abruptly in rims that are brightest toward the center of the principal clustering of stars (in the left central part of the field). Fainter bright rims show up well in the lower right of the picture. Compare this nebulosity with the Horsehead nebula on the back cover. The scale of this reproduction is approximately 3.3 seconds of arc per millimeter. South is at the top, and east at the right. Mount Wilson and Palomar Observatories photograph.

multiple reflections from other particles; and very little emerges outward, in the direction of the observer. In the case of particle *P*, most of the scattered radiation also disappears inside the cloud, but the minimum of scattered light is directed toward the zenith of the particle in question, now at right angles to the line of sight of the observer. The amount of light seen by the observer is considerably greater in this case than in the case of particle *Q*. As a result, the edge of the dark nebula is more luminous, by reflected starlight, than the center.

The mathematical computations that are required to derive the distribution of the dotted arrows confirm this qualitative discussion. If the surface brightness of the dark cloud is designated as unity, that at about nine tenths of the distance toward the extreme edge may be two or three units, depending upon the degree of concentration of each scattered beam in the forward direction.

Of course, in reality there are no *sharp* edges. The dark nebulae merge continuously with the background illumination of the night sky, the spaces between the stars shining partly by the diffuse reflected radiation of the interstellar substratum (of which the clouds are the most conspicuous condensations), and partly by the light of unresolved faint stars. To this is added the feeble glow of the zodiacal light and the emission of our own atmosphere. These latter two sources are added to the light of the cosmic clouds, and reduce the contrast between center and edge.

Before we leave the subject of the dark clouds, attention may be called to a phenomenon which in some respects resembles the break-throughs discussed by Thackeray. Among the dark clouds there are many which have an elongated shape, and some resemble long, irregular lanes, with stars at their ends. The most famous lanes of this sort are the ones that extend from the region of Sagittarius and Ophiuchus, westward, and end in the group of stars which includes Rho Ophiuchi, Sigma Scorpii, Antares, and 22 Scorpii. Wide-angle photographs of this region by F. E. Ross in his famous *Atlas* (see back cover, *Sky and Telescope*, September, 1943) and more recently by Osterbrock and Sharpless with the Henyey-Greenstein camera, give the impression that the dark lanes are left behind by the stars in their forward motion, somewhat like a plume of smoke left trailing behind a steam locomotive.

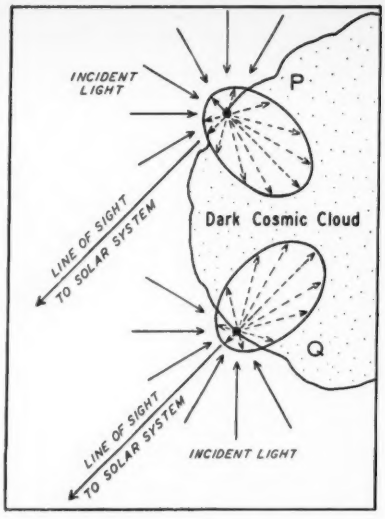


Fig. 3. The continuous arrows indicate the uniformity of the incident light from the starlit hemisphere as "seen" by each particle on the surface of the cloud. The dashed arrows represent the same distribution of scattered light for each particle, but the particle Q in the "center" of the cloud sends less light toward the solar system observer than particle P, which is observed by him near the edge of the cloud.

But the physical causes of the two phenomena must be different. The smoke plume is retarded by friction with the air. The interstellar clouds of smoke do not encounter such friction; whatever friction there may be with the substratum of the galaxy would not be sufficient to draw the cloud out into a long lane. It is more likely that the stars pass through a region that is inherently rich in interstellar material, and that in passing through it they somehow alter the character of the particles, rendering them more opaque to the light of distant stars. This would resemble, on a tremendous scale, the tracks of various high-energy particles in a Wilson cloud chamber.

We have no physical process in mind, at the present time, that would accomplish this transformation. But it would be interesting to know whether the proper motions of the stars at the heads of the dark lanes are directed along these lanes. Surely, there must be enough information on proper motions in the existing star catalogues to answer this question!

In Focus

MT. HAMILTON in California is changing in appearance rapidly these days, as the massive dome of the 120-inch reflector of Lick Observatory rises to the sky. Frank Kettlewell, of the art department of the Oakland **Tribune,** a member of the Eastbay Astronomical Society, took the front-cover photograph during the third week in May. Since then, additional sections have been added to the dome, which is scheduled for completion in early fall.

The new building is 97 feet in diameter and 94 feet high. The extension low on the left contains the coude spectrograph room (almost entirely underground), and the time-standard room. Within the dome may be seen the 115-foot derrick for rigging the sections. In the left background of the picture are earlier Lick buildings, including the domes for the 36-inch and 12-inch refractors. Between these and the 120-inch building is the housing of the 20-inch double astrographic camera.

The 120-inch blank for the new telescope will be ground and polished in the dome itself; both horizontal and vertical testing will be carried on. A concrete-walled light tunnel, 11 feet square in cross-section, will extend underground 73 feet beyond the outer wall of the building. In the top of the dome a knife-edge test stand will be mounted, on the carriage of the 15-ton crane, 11 feet from a 14- by 21-inch diagonal flat, located 89 feet above the 120-inch mirror.

On the second floor of the new building there will be offices, service rooms, and the visitors' gallery, on the same style as that in the 200-inch dome on Palomar Mountain. The east entrance, seen in the front-cover photograph, is large enough to permit trucks to drive in and stop under a large hatch in the second floor.

A model of the new Lick reflector was pictured on the front cover of **Sky and Telescope** for January, 1947, but some changes in this design have been necessitated by the purchase of the 120-inch ribbed disk, weighing 8,000 pounds, which was originally intended as a testing flat for the 200-inch telescope mirror. It had been expected to use a 16,000-pound solid mirror. The final design drawings of the fork-type mounting are nearing completion.

As in the 200-inch instrument, the observer will ride in the prime-focus cage. Glass blanks for five auxiliary mirrors, ranging up to 50 inches in diameter, have been obtained from Pilkington Brothers in England.

A new photograph of the Horsehead nebula from the 200-inch Hale telescope is published on this month's back cover. A wealth of detail not present on pictures made with smaller instruments attests the excellence of the Palomar reflector. Note the light and dark regions in the head of the Dark Bay nebula, as Barnard called it, the delicate shadings in the regions where bright and dark nebulosity adjoin, and the long parallel dark streaks in the bright half of the field. The Horsehead furnishes good examples of the "silver linings" discussed by Dr. Otto Struve in this issue.

The Horsehead nebula, appearing as a "semicircular indentation five minutes of arc in diameter 30 minutes south of Zeta Orionis," was discovered photographically with the 8-inch Bache refractor of Harvard Observatory in 1887. It is numbered 434 in the **Index Catalogue,** which supplements Dreyer's **New General Catalogue.** Its position below Orion's belt is shown on page 45 of the December, 1948, issue of **Sky and Telescope.**

BOOKS AND THE SKY

INTRODUCING THE UNIVERSE

James C. Hickey. Dodd, Mead & Company, New York, 1951. 154 pages. $3.50.

THE AUTHOR of this book is a newspaper writer, who has had astronomy as a hobby since he was a boy. He recently retired as the writer of the "Stars of the Week" column in the late New York **Sun.** Some of the chapters in the book originally appeared in this column, which ran for 15 years.

This book can be recommended as a brief but interesting introduction to astronomy. About half of it is devoted to the solar system, 20 per cent to the constellations, and 10 per cent each to history, miscellaneous items, and the universe beyond the solar system.

There are four end-paper star maps, showing the evening sky at the four different seasons. In some cases the lines connecting the principal stars in a constellation were made so fine in the original drawing that they were not reproduced in printing. There are 15 pages of good photographs, all but one of which are located together at the middle of the book.

Aside from the star maps, there are no diagrams. There are many topics in astronomy which can be explained much more clearly with the aid of diagrams than with just words alone. Examples are lunar phases, eclipses, orbits of planets and comets, relative sizes of celestial objects, the sky at different latitudes, and precession.

The book is up to date and remarkably free from errors. The only ones found are of a very minor nature. On page 10, the number of miles in one light-year is given as the number in 3.258 light-years. On page 15, the mass of the third body in the double star system of 61 Cygni is correctly quoted as 16 times that of Jupiter, but incorrectly stated as 4,070 times that of the earth. Since the mass of Jupiter is about 317 times that of the earth, the figure should be about 5,070.

On page 27, the reason given for the half moon being only one ninth as bright as the full moon is that the sunlight is reflected chiefly in a direction perpendicular to the surface. The point which should be brought out here is the rough character of the lunar surface, which causes it to be partly darkened, except at full moon, by the shadows cast by its own irregularities. Mercury shows this same effect, but Venus does not. The reason is that Venus is covered with clouds, which form a much smoother reflecting surface.

C. H. CLEMINSHAW
Griffith Observatory

THE YERKES COLLECTION OF ASTRONOMICAL PHOTOGRAPHS

Edited by **Thornton Page.** University of Chicago Press, Chicago, 1951. 36 pages. A catalogue available on request from the Photographic Service Department, Yerkes Observatory, Williams Bay, Wis.

"SINCE 1903 the Yerkes Observatory of the University of Chicago has been reproducing, in lantern slides, transparencies, and prints, the original astronomical photographs made at Williams Bay. Copies of photographs made at other observatories have been added to this collection in recent years. These reproductions are sold by the University of Chicago Press and are listed here for the convenience of the general public and for the student, the scientist, the author, and the lecturer, in whose work accurate illustrations are required."

Thus begins the latest edition, just published, of the illustrated catalogue of Yerkes Observatory slides, transparencies, and prints. The entire collection at Yerkes was revised and recatalogued during the past year by Dr. Thornton Page, of the Yerkes staff. Of the more than 800 entries in the new edition, 170 are illustrated. New subjects include Harvard Observatory photographs of southern objects, such as the Magellanic Clouds and Omega Centauri.

The Yerkes set of 100 selected slides, standard for many years for teachers and lecturers, has been revised to include new subjects, for instance, the discovery photographs of the new satellites of Uranus and Neptune (1948-49), and spectral classifications by Morgan (1950). New diagrams of the solar system, of the galaxy, and of the Russell-Hertzsprung plot of stellar luminosities and spectral types are also included. The descriptive cards for the 100-slide set, each bearing 200 to 250 words, have been rewritten and revised.

The 100 selected slides, mounted 3½ by 4 inches in glass, are priced at $75.00, plus shipping charges, and the set of descriptive cards is $3.00. Sixty of these slides are now offered in 2 by 2 size ($25.00), and on 35-millimeter filmstrip ($5.00). The set of 60 cards is $2.00.

C. A. F.

NEW BOOKS RECEIVED

CLIMATE IN EVERYDAY LIFE, *C. E. P. Brooks*, 1951, *Philosophical Library*. 314 pages. $4.75.

In three parts, this book has as its purpose assisting the reader to make the best of the climate in which he lives. The author, who wrote *Climate Through the Ages*, discusses Living with the Climate, Climate as an Enemy, and The Control of Climate.

JOHANNES KEPLER: LIFE AND LETTERS, *Carola Baumgardt*, 1951, *Philosophical Library*. 209 pages. $3.75.

A biography of the great 17th-century astronomer, with five chapters ranging from "Youth and Years of Apprenticeship," through "The Odyssey of the Last Four Years," includes translations of many of his letters.

ROCKETS, MISSILES, AND SPACE TRAVEL, *Willy Ley*, 1951, *Viking*. 436 pages. $5.95.

This book on space flight has much new and up-to-date material, and also includes information from the author's earlier books, *Rockets* and *Rockets and Space Travel*, which went through five editions since 1944. The contents include historical material as well as current accomplishments and future plans.

INTERPLANETARY FLIGHT, *Arthur C. Clarke*, 1951, *Harper*. 164 pages. $2.50.

The author, assistant secretary of the British Interplanetary Society, subtitles his book, An Introduction to Astronautics, and states that it is "intended as a survey of the possibilities and problems of interplanetary flight, as far as they can be foreseen at the present day."

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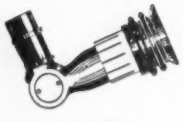

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EDITED BY EARLE B. BROWN

How to Build a Quartz Monochromator — V

By Richard B. Dunn, *Harvard Observatory*

After the quartz crystals have been inspected for defects, the first task is to locate the optical axis of each of them. The interference plates must be cut so that their transmitting surfaces will be parallel to that axis. Remember that the axis is a direction, not a line, and that both the ordinary and extraordinary rays are undeviated along the optical axis.

There are several good ways of finding this direction accurately, including X-ray, etching, and optical techniques. For amateurs, the optical method outlined here is probably the easiest to set up. The technique is described in part in Strong's **Procedures in Experimental Physics** and in part in Heising's **Quartz Crystals for Electrical Circuits.** As given here the method is more refined than that used by the author in making his first filter, which was probably accurate in this respect to about 20 minutes of arc. Accuracy of axis location within one minute of arc can be obtained with this method, but such accuracy is not needed in an amateur-built monochromator.

Fig. 1 shows the author's present apparatus, which can be simplified if desired. It consists basically of a rotating table that can also be tilted, two polaroids, and a monochromatic light source. The telescope is not necessary, as a small hole can be used instead. A monochromatic diffuse background works quite well. The author used an emission-type glow nightlight sold in some dime stores; these bulbs consist of two electrodes in the shapes of elephants, horses, and the like. They give off a reddish glow that is sufficiently monochromatic. The mercury arc light works quite well, but is more expensive; filters can be used to isolate one line of the mercury arc spectrum.

The apparatus orients the axis of the crystal with respect to the axis of rotation of the optical axis locating device. If a quartz crystal with two parallel transmitting sides perpendicular to the optical axis is placed between the polaroids or on the glass plate of the device, a series of concentric interference rings is seen in the telescope. These rings represent areas of constant path difference between the ordinary and extraordinary rays. If the crystal faces are parallel to the optical axis, and the light travels perpendicular to it as in the filter, a hyperbolic pattern is seen.

The table can be tilted and adjusted until the rings run true. The testing pattern is visible only if the light is highly convergent or divergent. In thick sections (up to two inches), if the telescope is not used, hold the eye close to the polaroid and the latter close to the crystal surface. If the surface is already ground, a cover glass separated by Canada balsam or oil can be used to "clear" the surface enough to show the rings.

Beginning with the rough crystals, one first approximately locates the optical axis in the manner described below, and makes a saw cut approximately perpendicular to the optical axis. The first surface may be considered the preliminary index plane and axis corrections referred to it.

There are two simple ways of roughly locating the optical axis. The first and easiest is to look at the crystal faces and the striae in the surfaces and visualize the direction of the optical axis, which runs

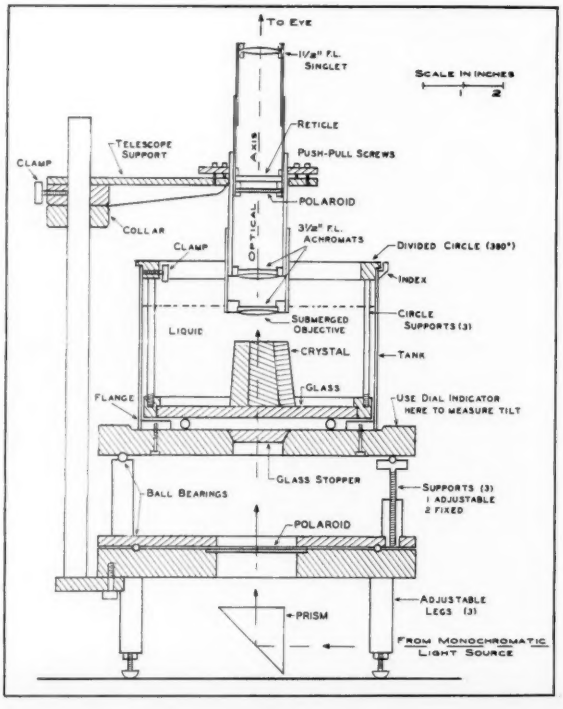

Fig. 1. The apparatus that is used for locating the optical axis of a crystal of quartz. The telescope contains two objectives, the lower one of which is removed for testing without the immersion liquid. As shown in the photograph opposite, the telescope may be swung to one side, and the crystal holder removed. The reticle is for checking the perfection of the interference rings.

The apparatus detailed in Fig. 1, with the crystal holder removed. A filter element may be seen on the glass supporting plate of this holder.

at right angles to these. Another method is to use the polarization properties of the crystal. With white light and visual testing, light along the optical axis is seen not to be reduced in intensity by rotating the second polaroid. At right angles to the optical axis (in the direction of transmitted light in the finished plate), one can reduce the intensity of the light by aligning the polaroid parallel or perpendicular to the optical axis instead of at 45° to it as in the finished plate. Essentially what one does, then, is to turn the crystal between polaroids until one of these conditions is fulfilled. This is a good method of locating the optical axis in thin plates. The method can be made precisely sensitive by making the second polaroid of two pieces of polaroid set at a very small angle.

Then immerse the entire crystal in the liquid shown in Fig. 1, so the preliminary surface rests on the glass plate. A mineral oil of the same index of refraction as the ordinary ray of quartz should be used, as this "eliminates" the rough top planes and gives a practical transmission cell. Adjust the rotating plate by tilting and by rotating the crystal until the concentric rings run true. Lay out the angle, as indicated by the dial indicator and the top index circle, on the preliminary surface. At this point, it is useful to have another surface parallel to the index surface to correct the index surface. Saw this opposite face (the end of the crystal from which the testing light emerges) and grind it with carborundum until it is approximately parallel to the index surface.

Grind away the correcting angle on the index surface. Parallelism can be achieved just by constantly pushing down on the side of the crystal that is thickest. A wedge-shaped correction ⅛" thick can be made in less than an hour. Quartz is hard, but it is brittle and tends to break easily under the action of the carborundum. In the final stages, the two surfaces can be made parallel and the angle can be controlled with a micrometer equipped with ball or pointed anvils.

Kerosene is a good immersion fluid for final testing. It does not have the same index as quartz, but Heising shows that it takes into account the ring eccentricity when the telescope is centered on one of the outer rings, and it may be used for partly finished surfaces. If no immersion liquid is used, the index surface and the surface parallel to it should be truly parallel, and all the angles should be divided by about 1.5 to compensate for the change in direction of the apparent optical axis due to refraction at the exit surfaces of the crystal.

Whether an immersion fluid is used or not, the axis is located when the revolving plate is perpendicular to the axis of rotation and the rings stand still when it is revolved. The polaroids should not rotate with respect to each other. Measure the tilt and the rotation of the crystal from a reference line.

Keep repeating the procedure until the dial indicator shows no deflection. Make the top surface precisely parallel to the index surface and fairly flat, and make a final reading and correction. You now have two accurate surfaces perpendicular to the optical axis. Call one of these the "final index surface," and make all further right-angle cuts relative to it.

The next step is to reduce the crystal to final thickness (final aperture dimension) and to square up the crystal by cutting a surface perpendicular to the index surface, parallel to the optical axis. All of these surfaces are to become the edges or sides of the finished plate. Square sides are used because they give positive orientation; it would be easy to misalign the blocks if they were round. Besides, the square plates are probably easier to make. Squaring can be done by sawing and then grinding. The sides should be continually checked with a square and a micrometer. The final side should be checked against the other three for thickness and aperture.

You now have blocks of quartz with their ends (transmitting surfaces) untouched. These are to be sawed at right angles to the four surfaces already cut. If the worker has several crystals from which to cut his plates, he can mount them all in plaster and grind and polish the transmitting surfaces simultaneously. Sliders of quartz should be used to keep the edges from "turning over" and from chipping. The crystals can be aligned with a precision square and then set on a glass plate with a little beeswax; plaster is then poured over the pieces. When the assembly has hardened, the work can be slid off the glass plate and the plaster can be cut down and shellacked.

There are two types of saws used in cutting quartz: the bow-wire and the circular. The first consists of one or two wires that are drawn across the material; emery, diamond, or carborundum is fed into these wires and the abrasive action cuts the crystal. The circular saw has a soft metal disk (of iron, aluminum, copper, or brass) that rotates with the grinding compound on its edge. If the abrasive material is allowed to flow onto the edge of the saw, the process is called muck sawing. If diamond dust is used, it is embedded in the edge of the saw by direct insertion or by rolling the grains in with a hardened steel roller. These saws run from 2,500 to 5,000 feet per minute. A

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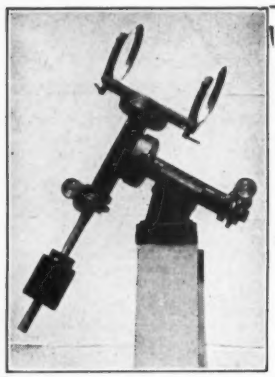
coolant of soapy water, kerosene, water-soluble oil, or washing soda is applied. The diamond saw is much faster than the bow saw, but it subjects the quartz to more thermal and mechanical shocks which are likely to cause surface cracks in the material. Nevertheless, a circular diamond saw is probably most suitable for this work. Ward's Natural Science Establishment in Rochester, N.Y., can supply them.



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It is wise to provide as much rigidity as possible in the sawing operation. An old belt-drive milling machine or a good solid lathe can be used if a professional saw is unavailable. The work should be securely clamped down before any cuts are made, and one must continually make corrections as the saws do not always cut true. This is especially true if the saw is too small for the work. The author used an 8" diamond saw on his lathe and found this none too large.

Grinding is best done on one of three annealed cast-iron laps kept flat by grinding against each other in every combination. This is the common procedure in making flats in optical work. A way to test for flatness is to place a piece of tinfoil under the edge of one of two laps that can be rotated on each other. If the rotation is stopped by the tinfoil, the surfaces are suitably flat. On the other hand, if the laps cannot be turned on each other, placing a piece of tinfoil in the center should allow them to turn if they are flat enough. Coarse grinding can be done with No. 120 carborundum, fine grinding with No. 220, and extra fine with No. 600. Emeries might be used to some advantage. Half-hour sessions with each grade should remove all pits and scratches from the preceding stage.

Polishing is done on a wax or pitch lap kept flat by pressing against one of the cast-iron lapping plates. The technique is the same as with any flat. The pitch can be hard because quartz is harder than glass. Optical rouge and cerium oxide work quite well on quartz. The latter is faster but more expensive. Polishing can usually be done in an hour and a half if pressure is used. If the surfaces are no flatter than two microns (about seven fringes when tested by interference on an optical flat with mercury green 5461 light), the filter will still work. After the ends of the crystals are polished, the crystals can be removed from the tool by using a chisel and hammer with care to break away the plaster.

Each element of the filter should then be sawed off and ground to about 0.020" thicker than the finished plate. The thinner plates should be cut first, as there will still be enough left of the index surface to make the faces square for a larger plate. If the large plates are cut first, and you are left with a plate only ⅛" thick, a square will not work well in squaring up the face to the ⅛" index surface that remains. An autocollimator would be an advantage. In any event, if the plate is thin, a cover of ¼" plate glass should be cemented to the surface with Canada balsam before the plate is sawed off. In this way, the author has experienced no trouble in cutting sections as thin as 0.025". After a component is sawed off, the sawed surface of the block is ground and polished before the next component is cut. As each component is cut from the squared crystal, it will have one side polished, and it will be of excess thickness by as much as 0.020".

Then each component should be mounted separately in a glass-backed tool by the following procedure. The unpolished side is placed flat against a glass plate. Cover glasses are placed all around to protect the edges; the cover glasses should be tapered so they will not come out of the plaster. A piece of glass can be cemented on the back of the crystal if it is thin. Plaster is used as before to hold the components in place. The whole assembly should be small enough to permit mechanically measuring the corners in addition to optically measuring the surfaces. Fig. 2 shows a cross-section for a thick and thin crystal. Plates thinner than ½" probably do not have to be mounted in the plaster with gliders; they can most likely be worked flat enough by themselves just as one makes a diagonal. Turned-down edges will have to be severe to be outside the tolerance.

One might wonder about the effect of strained glass or strained Canada balsam cement on the final testing procedure. No birefringent pattern of strain was noticed. This may just apply to the thin plates, as these were the only cemented plates. Perhaps the interference pattern is superimposed over a whole area. At any rate, the author with his simple apparatus could not detect any difference. For the very thin plates the glass was left on even in the final prism. The crystals are then ready to be tested and brought to final thickness.

For grinding and polishing the crystals to the final thickness, a testing apparatus similar to the one shown in Fig. 3 will be needed. It consists essentially of a per-

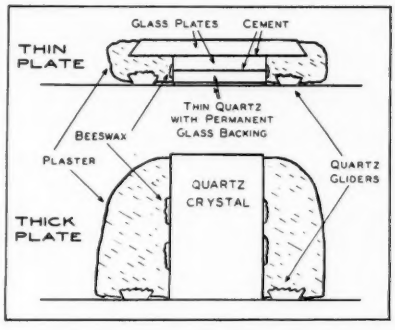

Fig. 2. The assembly for working the transmission surfaces of the elements.

pendicular beam of light passed through the polaroids and crystals to the spectroscope. A source of light, preferably the sun, is reflected through three circular diaphragms ⅜" in diameter. The beam is reflected upward by a 90° total-reflecting prism or by a mirror, through a polaroid, through the crystal, and through the second polaroid. The beam is then reflected over to a spectroscope. A means should be available to level the plate supporting the crystal. With the upper prism removed, the beam should be made perpendicular by adjusting the lower prism so that it strikes the support of a plumb bob. The beam should pass through the crystal at right angles, since a shift in incident angle means a shift in optical path through the crystal and results in a shift in the wave length of the transmission band.

If at all possible, procure a good spectroscope with a fair resolving power, high magnification, and large dispersion. You should be able to see shifts amounting to 1/20 d_0, or to roughly about half an angstrom in the red. The author barely got by with a typical classroom spectro-

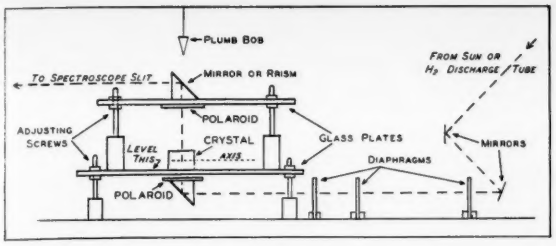

Fig. 3. The testing apparatus for determining the location of the transmission band in each crystal. Not shown is the spectroscope, in which the crosshair of the view telescope is set to the red of the hydrogen-alpha line to permit room-temperature tests.

scope, but which used two prisms and higher magnification than usual. The spectroscope need not have a calibrated circle or any type of device to indicate wave length. If prisms are used, the dispersion will be much less in the red than in the violet; with a grating the dispersion should be almost the same anywhere in the spectrum. It has been suggested that enough dispersion could be obtained from a series of sections of a war-surplus tank prism cut with a diamond saw. A long-focus lens helps to get a large separation between the transmission bands.

Set the spectroscope crosshair to the red of the hydrogen-alpha line a little more than twice the width of the separation of the sodium D lines, which are about six angstroms apart; the temperature correction is on the order of 12 to 20 angstroms. The plates can be figured to center the transmission band on the crosswire, and in the final filter can be heated up until they coincide exactly with Hα. If the polaroids are set parallel, and if the crystal is placed so that the optical axis is at 45 degrees, the spectrum will be seen to be broken into a series of bright and dark bands. One of these bands, to the red of the crosshair, is the band desired to be made to coincide with the crosshair, which will be done by reducing the thickness of the crystal element being tested.

First, however, test the parallel faces of the element, both with the micrometer and optically: If there is any shift in the bands as seen in the spectroscope when the crystal is moved about in the beam, the crystal is not parallel. A shift toward the red means that the thickness is increasing.

When the micrometer reads that the crystal is 0.002" thicker than the finished size, there should be a bright band, slightly to the red but very near the crosshair. The fine grinding is continued until the band is almost centered on the crosshair, but a small residual correction should be left for polishing. This requires experimentation; the author usually ground until the band was as close as five or six angstroms before polishing.

Start this final testing procedure with one of the intermediate crystals, as the thicker crystals have many fine bands, and these are especially close together when low dispersion is used. The thinner crystals may be mechanically measured close enough to final thickness, but it pays to check them optically. The tolerance is the same for all the crystals — make them as perfect as possible.

As mentioned previously, if a mistake is made it is possible to make a plate a $\mathbf{d}_0$ thinner or perhaps just $\frac{1}{2}\mathbf{d}_0$ thinner. The second case would require crossing the polaroids if they were parallel, thus making all dark lines bright and all bright lines dark. A mica wave plate could also be introduced to help. Do not worry about the bands of small integers of $\mathbf{d}_0$ not superimposing elsewhere than in the red, for the glass filter will cut out those maxima anyway. In the final analysis, the filter elements can be stacked up, and if there are any residual bands left in the red, a plate of the proper thickness can be introduced to darken that band and leave the desired transmission band clear.

Once the elements are all tested and corrected, there remains the work of mounting the filter into a convenient cell and providing for temperature control.

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OBSERVER'S PAGE

Universal time is used unless otherwise noted.

Visual Observing Programs for Amateurs — XVII

Observing the Sun — (continued)

Solar Granulation Number. While sunspot counting, you will be vaguely aware that the sun's photosphere is not uniformly white all over but that it presents a mottled or "lemon-peel" finish. This is caused by the granulation of the sun's surface, which was discussed by Dr. Otto Struve in his article in the August, 1950, issue of **Sky and Telescope.** Hot turbulent clouds on the sun appear brighter than the interstices between them. Except in the steadiest seeing, individual granulations are not visible with a 3- or 4-inch telescope at moderate powers, but clumps or clusters of them may be large enough to be partially resolvable with such instruments.

Changes in the granulation pattern, with perhaps some aid from unsteady atmosphere and the retinal pattern of the observer's eye, produce an elusive mottling that is sometimes quite pronounced, while at other times it may be just detectable or even absent. Dr. James C. Bartlett, Jr., 300 N. Eutaw St., Baltimore 1, Md., is the leader of a group of Solar Division members who report on the presence or absence of this granulation each time they observe the sun.

In order to standardize conditions, most of the observers are using small refractors which they diaphragm down to a 2-inch aperture for granulation study only, and they use powers of about 32 to 40. If granulation is not visible, they report its daily index as 0; if just detectable, they report it as being of intensity 1, and so on up to an intensity of 5, which is the maximum and indicates that the mottling is quite pronounced. This may not occur more than one or two days a year, so that it may take a granulation observer some time to develop a sense of judgment. Once seen at intensity 5, the sun's appearance is never forgotten. The estimates of intensities 2, 3, and 4 are of necessity based on the observer's judgment. No exact criterion can be set up either for eye or photographic work, at least at present.

This study of granulation is too new to report any certain results, but in effect it is a study of the activity of the sun's photosphere.

Foreshortening of Sunspots. It is quite apparent after a few weeks' daily solar study that when spots are near the center of the sun they usually appear tolerably round. When near the limb, however, they appear elliptical or foreshortened. Does this foreshortening follow the simple geometrical laws which would apply to a round, flat disk on the sun, or is the foreshortening enhanced by a central concavity of the sunspot?

It is impossible to tell by direct measurement on the spots themselves, for so few of them are exactly round, but Dr. W. Gleissberg, University Observatory, Bayazit, Istanbul, Turkey, believes that it will be possible to tell by statistical means, based upon the reports that he has secured from Solar Division members.

These reports furnish information as to how many groups and spots are visible each day on the sun's meridian, how many lie a day east and a day west of the meridian, how many lie two days east and two days west, and so on up to seven days, which places spots on the east and west limbs of the sun. Only the largest spots can be seen at the extreme edges, and in general spots can be detected only six or 6½ days from the meridian. This Gleissberg study may be completed at the end of 1951, but at present it is in full swing, and the Solar Division has forms which are used for reporting.

Color in Sunspots. If a sunspot is seen to be colored, it should be reported to Dr. Bartlett, or to Dr. W. O. Roberts, High Altitude Observatory, Boulder, Colo. To me there is some mystery about color in sunspots, although the classical literature has many references to such phenomena. In 1946, I saw a peculiar pulsating brown color in a large sunspot; this effect lasted several minutes. For many months, while using a neutral Mogey filter, I saw a good many spots with rosy glows in their penumbrae, probably caused by the secondary spectrum in my short-focus refractor. With welding-glass filters and coated eyepieces, I have seen these rosy glows only once or twice. Dr. Bartlett frequently sees a dark violet shade in the umbrae of spots.

Some color effects may be physiological. Nevertheless, there remains a considerable bulk of reliable reports of color in sunspots; this deserves study and further elucidation by the accumulation of more reports when colors are seen.

Sudden Solar Activity. The sun is now well on the downward path toward minimum activity, which is predicted for the beginning of 1955, or perhaps late in 1954, so all forms of its activity, including sudden or unusual disturbances, may be less frequent for the next few years. As it is not known exactly what processes take place on the sun, no very specific instructions can be given as to what to look for in the sudden and unusual, but such manifestations may occur a few times a month on the average. Dr. Roberts, and Dr. D. H. Menzel, Harvard Observatory, Cambridge 38, Mass., are especially interested in reports by experienced amateurs.

Here are a few examples and suggestions of what to watch for: Over a year ago I saw a small inconspicuous group of spots that had not been present the day before. The next day it was a large group, and the day after it was a huge **F**-type group of the largest and most active kind, with all its components in a turmoil of activity. On another occasion, the umbra of the preceding large spot of a smallish **E** group began to be pinched in on its north and south sides by bright protruberances so that it resembled an hourglass in shape. Eventually these pushed in clear across the umbra, forming a bright bridge which divided the umbra in two.

Sometimes a rash of pores will appear between two existing complex spots, and

they may eventually coalesce into one larger group. Sometimes a once-active group which has largely disintegrated into a couple of stable **H** groups will suddenly renew its activity, apparently draw surrounding spots toward itself, and will become again an **E** or even an **F** group. Sometimes the leading spot or spots in a large group will show considerable internal motion.

Rotation in Sunspots. Francis P. Morgan, of the Montreal Centre, Royal Astronomical Society of Canada, has done considerable work on direct visible evidence of rotation in sunspots (**Journal,** RASC, November-December, 1948), and has made many drawings indicative of slow rotation of some spots. Other observers, especially those gifted in sketching and with considerable midday time at their disposal, could well take up this work.

Aurorae Observations. There seems little doubt that the northern and southern lights are an indirect manifestation of solar activity. Reports on aurorae are desired, and Donald H. Kimball, Yale Observatory, Prospect and Canner Sts., New Haven 11, Conn., chairman of the auroral committee of the AAVSO, is prepared to furnish instructions and forms to those in a position to do such work. His analyses of the observations reported to him will be made available to the Foundation for the Study of Cycles and to Dr. C. W. Gartlein, of Cornell University, who has headed up the Cornell-National Geographic Society study of aurorae for the latest solar cycle.

Migratory Birds. Observers of the sun often see migratory birds crossing in front of the solar disk. I have not seen many of these in recent years, for apparently I do not live beneath one of the great flyways followed by the birds. However, I have at times seen birds flying at great heights, some of them taking several seconds to cross the sun. Once I saw a flock of 25 birds. The identity of such birds is, of course, difficult to ascertain, but I believe I have seen ducks several miles in the air, also a crane or heron at an even greater height. Airplanes and weather balloons appear against the sun, and may be seen when at great distances from the observer.

What is wanted are reports on migratory birds seen flying north from March 15th to June 30th each year, and south from August 15th to October 31st. Observers will have to make their own report blanks, which should show the place of observation, date, time, size and kind of telescope and method of observing, state of the sky, direction and intensity of wind, and the height of the sun above the horizon. The apparent direction of bird flight should be given. These reports should be sent to Mr. Heines, who will forward them to Drs. William A. Rense, physicist, and George H. Lowery, Jr., ornithologist, of Louisiana State University, Baton Rouge, La.

As these birds always appear unexpectedly, and the period during which one can see them while crossing the sun is limited to a few seconds at most, it is not possible to be very exact in one's observations. When I see such a phenomenon, I mark an arrow across my daily sketch of the sun, showing where the bird crossed it, and note down appropriate details before returning to sunspot counting. Later I can fill in my bird-reporting form giving the data observed.

DAVID W. ROSEBRUGH
79 Waterville St.
Waterbury 10, Conn.

OCCULTATION PREDICTIONS

August 11-12 **Tau Scorpii** 2.9, 16:32.8 −28-07.0, 9, Im: **F** 5:07.0 −1.6 −1.6 115; **H** 4:21.6 −2.1 −0.5 92; **I** 4:11.3 −1.6 −0.3 77. Em: **H** 5:41.6 −1.7 −1.1 280.

August 16-17 **Delta Capricorni** 3.0, 21:44.3 −16-21.0, 14, Im: **A** 1:07.2 −0.9 +1.3 88. Em: **A** 2:09.8 −1.1 +1.8 220; **B** 2:13.8 −1.1 +1.7 224; **C** 1:58.1 −1.1 +2.0 217; **D** 2:04.4 −1.0 +1.8 225.

August 17-18 **Lambda Aquarii** 3.8, 22:50.1 −7-50.5, 15, Im: **A** 8:57.3 −1.2 −0.8 79; **B** 8:54.3 −1.0 −0.5 68; **C** 8:54.1 −1.5 −0.8 84; **D** 8:48.6 −1.1 −0.2 65; **E** 8:33.9 −1.3 +0.5 55; **F** 8:17.3 −1.9 +0.7 63; **G** 8:38.9 ... ... 338; **H** 7:58.9 −0.4 +2.6 5. Em: **A** 9:55.4 −0.3 +0.7 210; **C** 9:51.0 −0.2 +1.1 202; **D** 9:53.4 −0.5 +0.3 222; **E** 9:44.5 −0.9 +0.4 227; **F** 9:30.6 −0.9 +1.3 213; **G** 8:57.0 ... ... 308; **H** 8:54.1 −2.8 −0.1 274.

August 22-23 **Epsilon Arietis m** 4.6, 2:56.4 +21-08.7, 20, Im: **H** 7:58.2 −0.5 +1.2 92. Em: **G** 9:29.7 −0.5 +2.2 227; **H** 8:53.3 +0.1 +2.5 209; **I** 9:22.5 −0.4 +2.0 237.

August 23-24 **q Tauri** 4.4, 3:42.3 +24-18.9, 21, Im: **A** 5:45.5 −0.6 +1.4 90; **B** 5:49.3 −0.4 +1.6 83; **C** 5:38.2 −0.4 +1.3 90; **D** 5:44.6 −0.2 +1.6 79; **E** 5:38.8 +0.2 +1.5 71. Em: **A** 6:46.0 −0.2 +2.4 221; **B** 6:52.8 −0.3 +2.3 228; **C** 6:36.8 −0.1 +2.3 221; **D** 6:46.9 −0.3 +2.1 233; **E** 6:37.8 −0.1 +1.8 243; **G** 6:53.0 0.0 +1.3 284.

August 23-24 **20 Tauri** 4.0, 3:42.9 +24-13.0, 21, Im: **B** 6:17.1 ... ... 129; **D** 6:07.9 −1.2 +0.6 120; **E** 5:56.3 −0.4 +1.0 108. Em: **B** 6:47.1 ... ... 182; **D** 6:45.6 +0.7 +3.3 192; **E** 6:41.6 +0.5 +2.5 206; **G** 7:08.8 +0.2 +1.7 249; **I** 7:08.9 +0.3 +1.5 255.

For standard stations in the United States and Canada, for stars of magnitude 5.0 or brighter, data from the American Ephemeris and the British Nautical Almanac are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard station designation, UT, a and b quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.

The a and b quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computations of fairly accurate times for one's local station (long. Lo, lat. L) within 200 or 300 miles of a standard station (long. LoS, lat. LS). Multiply a by the difference in longitude (Lo — LoS), and multiply b by the difference in latitude (L — LS), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your standard time.

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B +73°.6, +45°.6	**F** +98°.0, +31°.0
C +77°.1, +38°.9	**G** +114°.0, +50°.9
D +79°.4, +43°.7	**H** +120°.0, +36°.0
I +123°.1, +49°.5	

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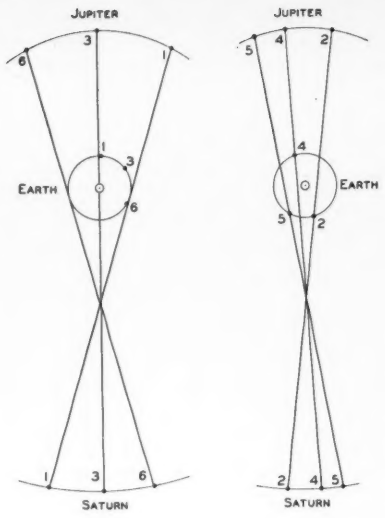
JUPITER AND SATURN

"TO CLASSICAL mythology, this special configuration might indicate a diametric separation of Power from Wisdom, with the latter virtue dominant." Thus did **Popular Astronomy** refer in March to the configuration of Jupiter and Saturn at that time. In August, Wisdom gives way to Power as Saturn becomes lost in the evening twilight and Jupiter attains a position of eminence in the night sky.

The way in which these two planets are pacing each other through this year is noteworthy. Except for brief intervals early this spring and this fall, with one or the other visible only against the dawn, the two are at no time above the horizon simultaneously during the night. This may be verified by the Graphic Time Table of the Heavens, published in January in **Sky and Telescope.**

This unusual circumstance results from the fact that the two planets come to mutual opposition to the sun on August 3rd, in the positions marked 3 in the diagram. Then, their heliocentric longitudes differ by 180°. The earth is then at position 3 also, and the Graphic Time Table shows that Saturn sets about half an hour before Jupiter rises. The planets are above the horizon together in the daytime half of the sky.

The extreme positions, 1 and 6, show the line joining the two planets tangent to the earth's orbit. These positions are for September 24, 1950, and May 25, 1952, respectively. Positions 2, 4, and 5, for



Current positions of Jupiter, Saturn, and the earth, with the orbits drawn to scale.

April 10, 1951, October 16, 1951, and February 21, 1952, respectively, are when the planets are at mutual opposition in geocentric longitude: the projections of the earth and planets lie in the same straight line on the ecliptic plane. These are nearly the times when one planet rises as the other sets. Because April 10th was such a short time after conjunction of Jupiter with the sun, and October 16th will be so near the conjunction of Saturn, it will require a very clear sky in order to see both planets at the same time in 1951.

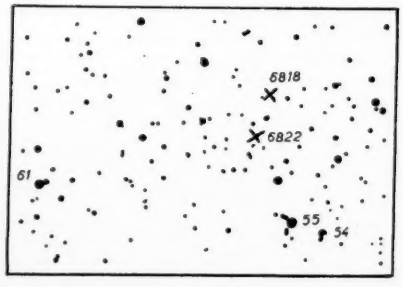
The exact dates when the two planets are simultaneously on opposite horizons varies appreciably with the terrestrial latitude of the observer; other factors involved are atmospheric refraction and the celestial latitudes of the planets.

PAUL W. STEVENS
2322 Westfall Rd.
Rochester 18, N. Y.

DEEP-SKY WONDERS

IN 1884, Edward Emerson Barnard, at that time an amateur, picked up a faint nebula in Sagittarius which has turned out to be a most interesting test object. Barnard saw it with a 4-inch instrument and noted that it showed even better with a finder. Larger telescopes often do not show it — Hubble notes that while "fairly conspicuous" in a 4-inch, it is almost impossible with the 100-inch. This galaxy, NGC 6822, $19^h\ 42^m.1$, $-14°\ 53'$ (1950), is a near neighbor of ours, being closer than the Andromeda spiral. It has an irregular shape much like the Magellanic Clouds.

Less than half a degree almost due north is the planetary NGC 6818, $19^h\ 41^m.1$, $-14°\ 17'$, $22''$ x $15''$, which Smyth terms "pale blue." It is a ring with two opposite sides brighter and a central darkness which may be seen under good conditions. It



The scale of this chart is 1° to 1 centimeter. The limiting magnitude is 9.

will stand medium powers for best visibility. Amateurs should not confuse these two; use the accompanying finder chart.

We have been getting reports on the objects listed in the May and July **Sky and Telescope,** and we will appreciate any comments on the visibility of these two objects also. As they both are difficult, although a 3-inch will show either, they must be looked for on fine evenings.

WALTER SCOTT HOUSTON

PHASES OF THE MOON

New moon	August	2, 22:39
First quarter	August	10, 12:22
Full moon	August	17, 2:59
Last quarter	August	24, 10:20
New moon	September	1, 12:49

	August	Distance	Diameter
Perigee	15, 4^h	225,000 mi.	33′ 00″
Apogee	27, 3^h	251,600 mi.	29′ 31″
	September		
Perigee	11, 20^h	228,200 mi.	32′ 33″

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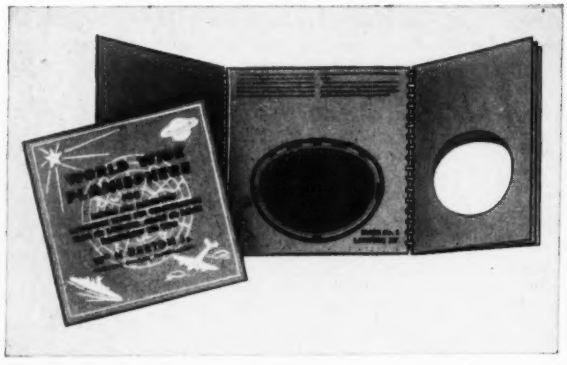

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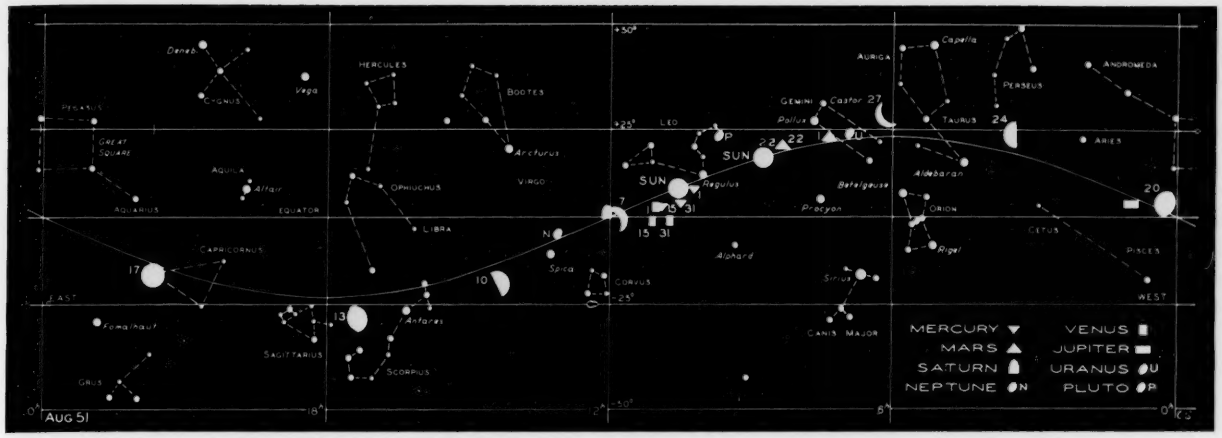


THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month and for other dates shown.

Mercury is east of the sun all month after reaching elongation on August 3rd, 27° 19′ east. This is about the maximum angle obtainable, but Mercury will set only one hour after the sun in mid-northern latitudes, about double this in mid-southern. The planet is at +0.6 magnitude.

Venus, rapidly approaching inferior conjunction with the sun on September 3rd, is also unfavorably located for northern observers. It is visible for the first two weeks of August low in the west at sunset. On the 14th, Venus appears at −4.0 magnitude, with the disk close to 49″ in diameter and only about 13 per cent illuminated. The crescent of Venus may easily be discerned with field glasses about this time. In southern latitudes, the planet can be followed with the naked eye until conjunction, 8½° south of the sun.

Mars leaves the morning twilight zone in early August, rising two hours before the sun. Moving through Gemini and Cancer, the planet is fainter than Castor, and quite inconspicuous.

Jupiter appears above the eastern horizon about two hours after sunset as a brilliant object, of −2.3 magnitude on the 15th. For the remainder of the year, it will be well placed for telescopic observation. The planet's equatorial diameter is now 46″. Its disk is visible, together with the four Galilean satellites, in moderate-sized binoculars.

Saturn sets 1½ hours after sunset in mid-August. It is to the west of (below) Spica. This planet will be of little interest until winter.

Uranus is in the morning sky in central Gemini.

Neptune is poorly located for observation, in the western sky at sunset.

E. O.

VARIABLE STAR MAXIMA

August 3, R Octantis, 7.9, 055**86**; 3, T Ursae Majoris, 7.9, 123160; 4, R Hydrae, 4.6, 132**422**; 6, T Cassiopeiae, 7.8, 001755; 10, T Aquarii, 7.9, 204**405**; 11, S Pavonis, 7.3, 194**659**; 20, R Corvi, 7.6, 121**418**; 22, R Aquilae, 6.3, 190108; 27, RT Hydrae, 7.6, 082**405**; 28, R Cygni, 7.3, 193449.

September 3, R Centauri, 5.9, 140**959**; 4, S Carinae, 5.7, 100**661**; 4, R Virginis, 6.9, 123307; 5, X Monocerotis, 7.6, 065**208**.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the predicted magnitude, and the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern).

MINIMA OF ALGOL

August 1, 4:02; 4, 0:51; 6, 21:39; 9, 18:28; 12, 15:16; 15, 12:05; 18, 8:53; 21, 5:42; 24, 2:31; 26, 23:19; 29, 20:08. September 1, 16:56; 4, 13:45; 7, 10:33.

These predictions are geocentric (corrected for the equation of light), based on observations made in 1947. See Sky and Telescope, Vol. VII, page 260, August, 1948, for further explanation.

JUPITER'S SATELLITES

Jupiter's four bright moons have the positions shown below for the Universal time given. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, eclipses and occultations by black disks at the right. The chart is from the American Ephemeris and Nautical Almanac.

Configurations at 7h 0m for an Inverting Telescope

Aug.	West	East
1	1	2
2	3 2 4	1
3	4	1 2	3
4	4	1 2
5	4	1 2	3
6	4	2	1 3
7	4	1	2
8	2	1 2
9	3 2 4		1
10	3 1		2
11		1 2	4
12	1 2		3 4
13	2	1 3	4
14	3 1	2	4
15	3	1 2	4
16	3 2		4	1
17	3	4
18	1 3 2
19	4 1 2	3
20	4 2	1 3
21	4 1 3	2
22	4 3	1 2
23	4 3 2	1
24	1 4	3 2
25	4	1 3 2
26	2 1 4	3
27	2	1 4 3
28	1	4
29	3	1 2	4
30	3 2 1	4
31	3 2 1	4

PREDICTIONS OF BRIGHT ASTEROID POSITIONS

Ausonia, 63, 9.5. Aug. 2, 22:54.5, −9-06; 12, 22:47.3, −9-22; 22, 22:38.1, −9-43. Sept. 1, 22:28.1, −10-04; 11, 22:18.5, −10-22; 21, 22:10.6, −10-34.

Ceres, 1, 8.0. Aug. 12, 23:25.7, −19-57; 22, 23:19.4, −21-07. Sept. 1, 23:11.6, −22-11; 11, 23:03.2, −23-03; 21, 22:55.0, −23-37. Oct. 1, 22:48.0, −23-51.

Hygiea, 10, 9.7. Aug. 12, 23:13.7, −0-15; 22, 23:07.7, −0-40. Sept. 1, 23:00.6, −1-15; 11, 22:53.2, −1-56; 21, 22:46.2, −2-38. Oct. 1, 22:40.3, −3-17.

Papagena, 471, 8.8. Sept. 1, 0:12.6, −25-59; 11, 0:05.8, −27-21; 21, 23:57.6, −28-17. Oct. 1, 23:49.2, −28-42; 11, 23:41.8, −28-32; 21, 23:36.5, −27-44.

After the asteroid's name is its number and the magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1951.0) for 0h Universal time. In each case the motion of the asteroid is retrograde. Data supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.

AUGUST METEORS

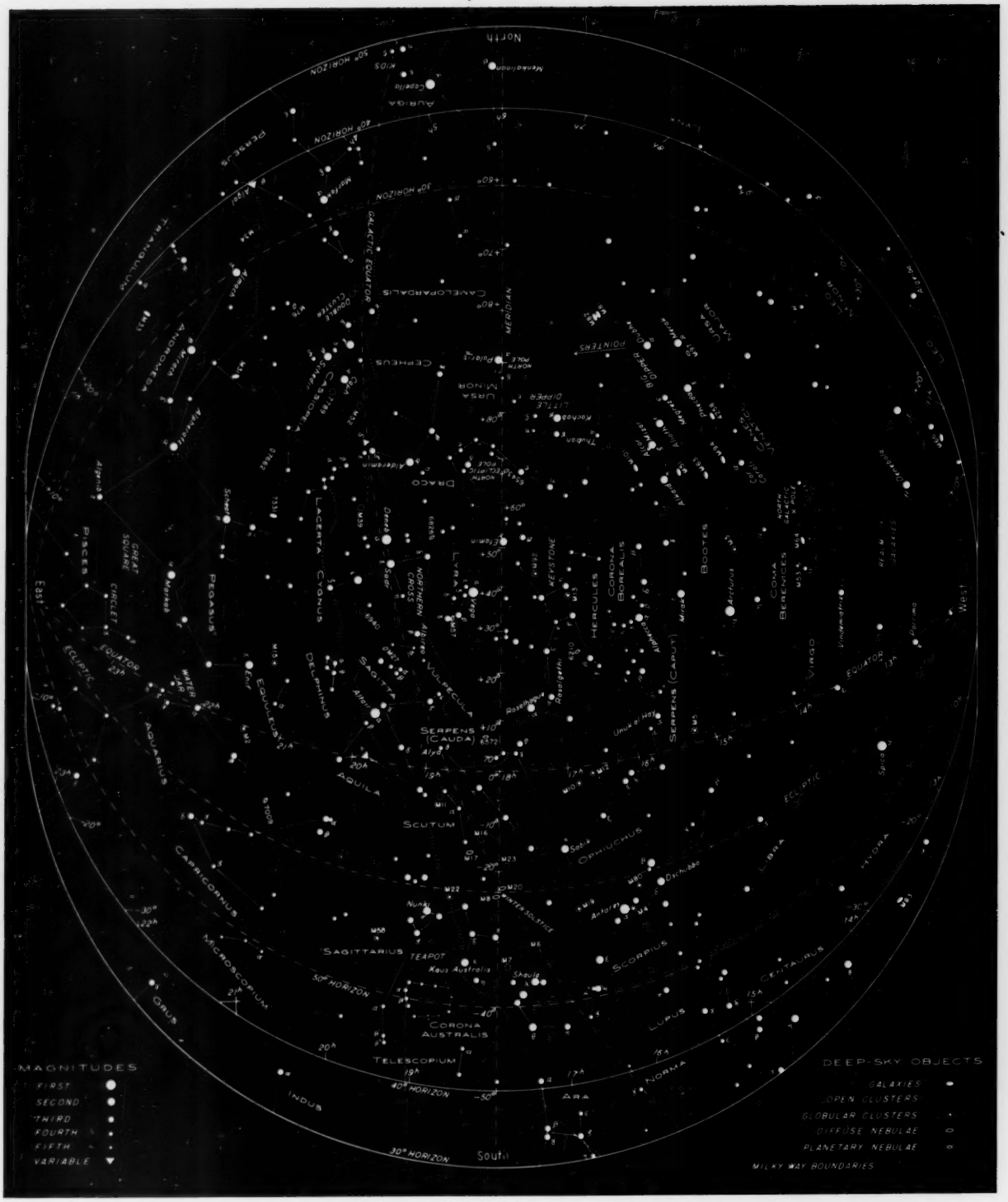
August is considered to be "meteor month," for it has the highest average rate of meteors of the year, with the rich Perseid shower mainly accounting for this. The Perseids, beginning in late July, slowly increase in intensity until August 11-12, then sharply drop off. At maximum, from August 9th through 13th, rates are generally 50 to 70 meteors per hour under favorable conditions. About 85 per cent of all meteors seen then will be Perseids, with at least 25 per cent leaving trains. The radiant is diffuse and of the moving type, north of Eta Persei at maximum. Observers should watch various regions of the sky, for the farther a meteor appears from the radiant, the longer its path is proportionately.

This year, first-quarter moon is August 10th, when its low declination causes it to set an hour before midnight; on August 13th it is at −28½° in Sagittarius. Therefore, until August 12th we shall enjoy a moonless sky after midnight.

E. O.

UNIVERSAL TIME (UT)

TIMES used on the Observer's Page are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown.



The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of August, respectively.

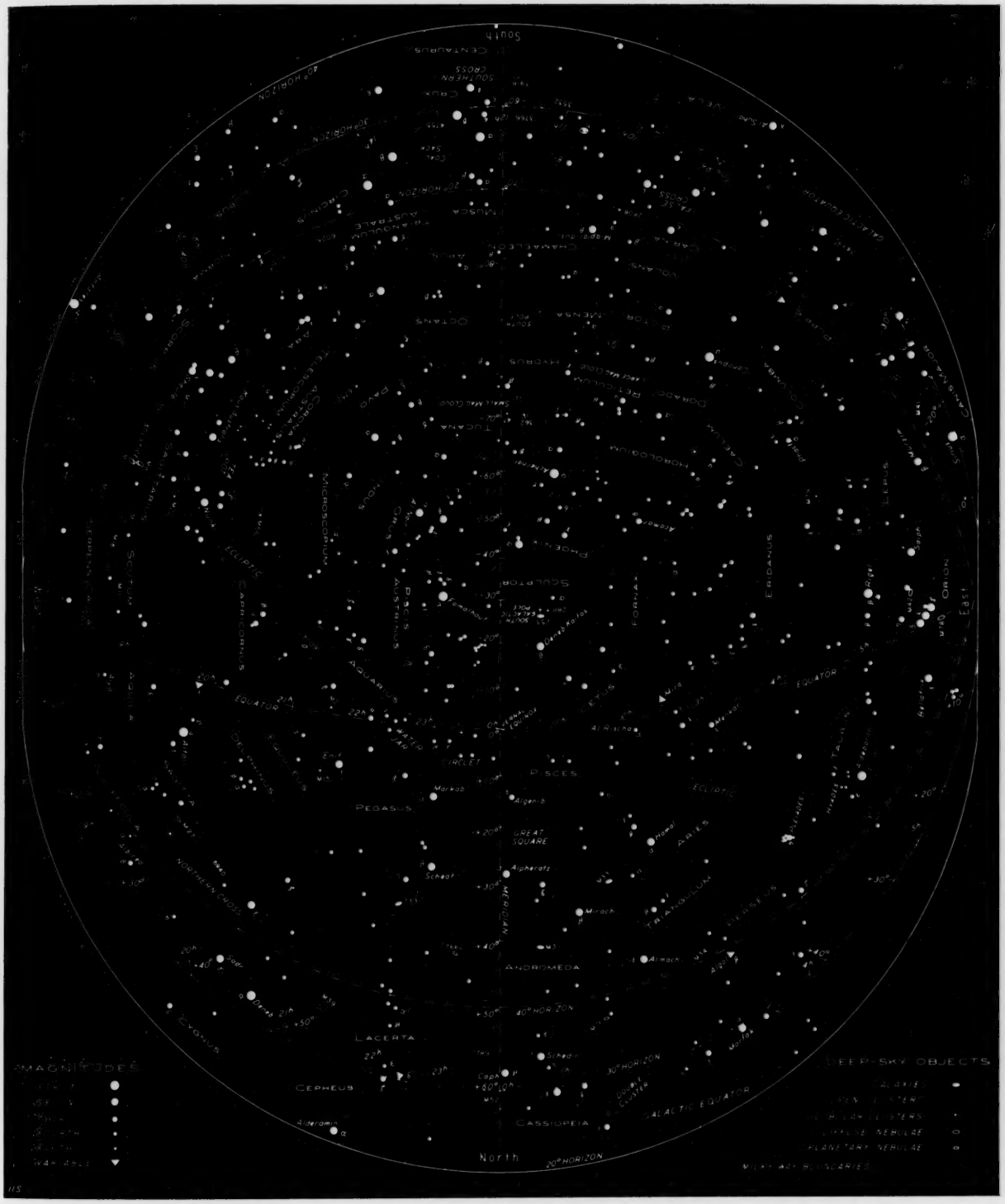
STARS FOR AUGUST

ALTHOUGH the brilliant stars of the summer Milky Way dominate August skies, lesser lights may occupy some of the stargazer's time during this month. Two rather neglected constellations of the zodiac can be studied. Libra, to the west of the meridian, is roughly a quadrilateral; its brightest star is Beta (β), of magnitude 2.74. Capricornus is roughly a triangle, where the easternmost star, Delta (δ), is brightest, of magnitude 2.98.

The two celestial crowns, Corona Borealis and Corona Australis, may be compared. The Northern Crown is easily found next to Bootes, with Alphecca serving as a guide to its nearly complete circlet. The Southern Crown has no stars brighter than magnitude 4.12, and is located south of the principal stars in Sagittarius. Observers in mid-northern latitudes should be able to pick it out with a clear sky and a good southern horizon. Its inconspicuous neighbors, Microscopium and Telescopium, are credited to Lacaille, but Corona Australis is one of Ptolemy's original 48 constellations.

Other information about Lacaille constellations is on the facing page.

CHART CORRECTION: In this chart the Greek letters for Alpha and Beta Cassiopeiae should be exchanged.



The sky as seen from latitudes 20° to 40° south, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of November, respectively.

SOUTHERN STARS

AROUND the south celestial pole, but in an area eccentrically located with respect to it, virtually every constellation may be attributed to either Bayer or Lacaille. Bayer, when he published his **Uranometria** in 1603, included 12 new constellations, whose formation he attributed to navigators of the early part of the 16th century, according to Allen. Of these, Apus, Chamaeleon, Hydrus, Tucana, and Phoenix are on the meridian of this month's chart. Lacaille, in 1752 and 1763, introduced 14 new groupings, honoring John Hadley's invention of the octant in 1730 by his naming of Octans.

Sculptor, the Sculptor's Workshop; Fornax, the Furnace; Caelum, the Graving Tool; Pictor, the Painter's Easel; and Circinus, the Pair of Compasses, are constellations formed by Lacaille, who assigned names "of the principal implements of the sciences and fine arts." Mensa, the Table, has been shortened and corrupted from the Mons Mensae of Lacaille, who named the constellation for Table Mountain in South Africa, often capped by a cloud as Mensa is capped by the Large Magellanic Cloud. Table Mountain had witnessed Lacaille's "nightly vigils and daily toils," for he was for several years at the Cape of Good Hope.